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CANADA
DEPARTMENT OF MINES
HON. MARTIN BURRELL, MINISTER; R. G. MCCONNELL, DEPUTY MINISTER.

MINES BRANCH
EUGENE HAANEL, PH.D., DIRECTOR

BULLETIN No. 27

Results of Forty-one Steaming Tests conducted at the Fuel Testing Station, Ottawa

BY
John Blizard, B.Sc.,
and
E. S. Malloch, B.Sc.

OTTAWA
J. DE LABROQUERIE TACHÉ
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LETTER OF TRANSMITTAL.

DR. EUGENE HAANEL,
Director Mines Branch,
Department of Mines,
Ottawa.

SIR,—

I beg to submit herewith, the accompanying report, prepared by Mr. John Blizard and Mr. E. S. Malloch, entitled "The Results of Forty-one Steaming Tests": which includes the results, and comments thereon, of all the steam boiler trials conducted at the Fuel Testing Station since this class of work was first undertaken.

I have the honour to be, Sir,

Your obedient servant,

(Signed) B. F. HAANEL,
Chief of the Division of Fuels and Fuel Testing.

OTTAWA, November 5, 1918.

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REPORT ON BOILER TRIALS CONDUCTED AT THE FUEL TESTING STATION AT OTTAWA.

INTRODUCTORY.

Since the publication of Report No. 331[1] on a series of boiler trials to ascertain the value of five fuels from Alberta for steam generation, and Bulletin No. 17[2]—which records a similar investigation for peat fuel, other boiler trials have been conducted at the Fuel Testing Station at Ottawa; the results of which, combined with the results of the trials already published, are embodied in the present report.

Inasmuch as the precise object of the boiler trials, and the method of conducting them, have already been described in Report No. 331, this information is not included in the present report. It may be well to point out, however, that the results of these trials should only be used comparatively, one with another, or with those obtained under similar conditions with other fuels.

ACKNOWLEDGMENTS.

All the coals in the trials were obtained through the office of Mr. John Stirling, Chief Inspector of Mines for the Province of Alberta. His co-operation greatly facilitated the work of this investigation.

The chemical division, under the direction of Mr. Edgar Stansfield, analysed and determined the calorific value of the fuels used, and analysed the flue gases produced during the trials.

Mr. A. W. Mantle, Mechanical Superintendent of the Fuel Testing Station, maintained the boiler in proper working condition, and assisted in carrying out the trials.

FUELS USED FOR THE TESTS.

Of the 19 samples in all, 18 came from the Province of Alberta. These coal samples were received from the following mine operators:—

West Central Alberta, and the Edmonton District:—

1. Jasper Park Collieries, Ltd.,
   Miette Mine, Pocahontas.
2. Mountain Park Coal Co., Ltd.,
   Mountain Park Mine, Mountain Park.
3. Yellowhead Pass Coal Co., Ltd.,
   Yellowhead Pass Mine, Coalspur.
4. Pembina Coal Operators, Ltd.,
   Pembina Mine, Evansburgh.
5. Cardiff Collieries, Ltd.,
   Cardiff Mine, Cardiff.
6. Twin City Coal Co., Ltd.,
   Twin City Mine, Edmonton South.

[1] Results of the Investigation of six lignite samples obtained from the Province of Alberta, by B. F. Haanel, B.Sc., and John Blizard, B.Sc.

[2] The Value of Peat Fuel for the Generation of Steam, by John Blizard, B.Sc.

Drumheller Coal Area:—

7. The Drumheller Land Co., Ltd.,
 Drumheller Mine, Drumheller.
8. Newcastle Coal Co., Ltd.,
 Newcastle Mine, Drumheller.
9. Midland Collieries Ltd.,
 Midland Mine, Drumheller.
10. Rosedale Coal and Clay Products Co., Ltd.,
 Rosedale Mine, Rosedale.

Cascade Coal Area:—

11. Canadian Pacific Railway Co., Dept. of Natural Resources,
 Bankhead Mine, Bankhead.
12. The Georgetown Collieries, Ltd.,
 Georgetown Mine, Canmore.

Blairmore-Frank Coal Fields:—

13. McGillivray Creek Coal and Coke Co., Ltd.,
 Carbondale Mine, Coleman.
14. Hillcrest Collieries, Ltd.,
 Hillcrest Mine, Hillcrest.
15. West Canadian Collieries, Ltd.,
 Bellevue Mine, Bellevue.
16. West Canadian Collieries, Ltd.,
 Greenhill Mine, Blairmore.
17. Franco-Canadian Collieries, Ltd.,
 Frank Mine, Frank.

Lethbridge Coal Area:—

18. Chinook Coal Co., Ltd.,
 Chinook Mine, Commerce.

For the purpose of simple identification, these samples are named as under:—

TABLE I.

List of Coals and corresponding trials.

No. of Coal.	Name of Coal.	No. of Boiler Trials A	B	C
1	Jasper Park	59	75	
2	Mountain Park	113	107	108
3	Yellowhead	60	74	
4	Pembina	55*		
5	Cardiff	52*		
6	Twin City	53*		
7	Drumheller	58	76	
8	Newcastle	61		
9	Midland	111	103	102
10	Rosedale	51*		
11	Bankhead	114	109	110
12	Georgetown	54*	77	
13	McGillivray Creek	69	78	
14	Hillcrest	112	105	106
15	Bellevue	67	80	
16	Greenhill	68	81	
17	Frank	70	79	
18	Chinook		100	101

* Results of trials 51, 52, 53, 54, and 55, have been published in Report No. 331.

All the trials mentioned in Table I, were conducted in a Babcock and Wilcox water tube boiler[1], having 677 square feet of heating surface. The trials referred to in column A, were conducted at a normal rate of steaming on a grate area of 23 square feet, with an air space of $\frac{1}{4}''$ between the bars; the trials in column B at a normal rate of steaming on a grate area of 21 square feet, with an air space of $\frac{1}{2}''$ between the bars; the trials in column C, were conducted using the same grate as for B, but at a higher rate of steaming.

The remaining sample, namely, No. 19, came from the government peat bog at Alfred, Ont. Six complete trials and one short supplementary trial have been conducted with this sample: four trials on the water tube boiler, and three on a fire tube boiler of the locomotive type. Bulletin No. 17 contains a full report of these trials.

RESULTS OF TRIALS.

A full report of each boiler trial appears at the end of this bulletin; but since the results of each trial are, principally, of comparative value, it is necessary, in addition, to show them in the form of tables and diagrams.

Table II compares:—

(a) The quantity of fuel burned to generate a definite quantity of energy, namely, 1,000 lbs. of steam from and at 212° F.

(b) The amount of ash, clinker, and refuse removed while generating the same definite quantity of steam.

(c) The fraction of the total solid refuse which was withdrawn by cleaning and slicing from above the grate bars.

(d) The difference in draft pressure below the bars, and in the flue leaving the boiler.

The cost of generating steam by the combustion of any one of these fuels will be proportional to the values assigned to each of the items in Table II, multiplied by some factor dependent upon the costs of the fuel per ton, labour, installation, and repairs to grates and settings, the production of draft, etc.; all of which vary with the site of the boiler room. An investigation of the magnitude of these factors is outside the scope of this report.

[1] For a description of this boiler, see Report No. 331, *loc. cit.*

TABLE II.

Four Principal Results of the Tests for each Fuel.

(*a*) Pounds of fuel fired per 1,000 pounds of steam, from and at 212° F.
(*b*) Total refuse removed per 1,000 pounds of steam, from and at 212° F.
(*c*) Ratio refuse removed from above the bars to total refuse removed.
(*d*) Draft between boiler exit and ash-pit; in inches of water.

No. of Fuel.	Name of fuel and general remarks.					
		Evaporation rate,		Normal.	Normal.	High.
		Grate area: sq. ft.,		23	21	21
		Air spaces in fire bars,		¼″	½″	½″
1	Jasper Park,	Run-of-mine coal, 5″ lump to dust, coal cakes, clinker in small pieces.	*a* *b* *c* *d*	146 33·0 0·81 0·64	151 38·5 0·35 0·59	
2	Mountain Park,	Run-of-mine coal, mostly 5″ lumps with much dust, coal caked, clinker in small pieces.	*a* *b* *c* *d*	125 17·7 0·91 0·42	125 21·8 0·44 0·20	127 17·7 0·34 0·76
3	Yellowhead,	Run-of-mine coal, mostly about 5″ lumps with little dust. Clinker spread over bars.	*a* *b* *c* *d*	144 15·0 0·86 0·47	145 19·6 0·41 0·17	
4	Pembina,	Run-of-mine coal, about 2″ to 5″ lumps, no small stuff. Clinker in small pieces easily removed.	*a* *b* *c* *d*	176 16·9 0·75 0·63		
5	Cardiff,	Run-of-mine coal, 4″ and 5″ lumps, to very small stuff. Hard clinker, forms in fairly large pieces, does not adhere to the bars.	*a* *b* *c* *d*	197 16·8 0·74 0·46		
6	Twin City,	Run-of-mine coal, not very much small stuff. Clinker in hard and not very large lumps, sticks slightly, does not spread over bars.	*a* *b* *c* *d*	191 17·7 0·79 0·63		
7	Drumheller,	Slack coal, containing much dust and dirt. Clinker formed rapidly and spread over the bars.	*a* *b* *c* *d*	212 43·2 0·79 0·64	270 65·3 0·38 0·73	
8	Newcastle,	Run-of-mine coal, 5″ lumps and smaller, very little dust. Clinker gave very little trouble, did not spread.	*a* *b* *c* *d*	175 16·8 0·85 0·41		
9	Midland,	Run-of-mine, fairly large lumps, not much small stuff. Clinker formed in large, thin slabs, easily removed.	*a* *b* *c* *d*	165 17·7 0·91	175 19·5 0·51 0·12	183 17·8 0·48 0·79
10	Rosedale,	Run-of-mine, lumps and small stuff, very little dust. Thin clinker, spreads on bars, sticks a little.	*a* *b* *c* *d*	184 14·4 0·83 0·57		

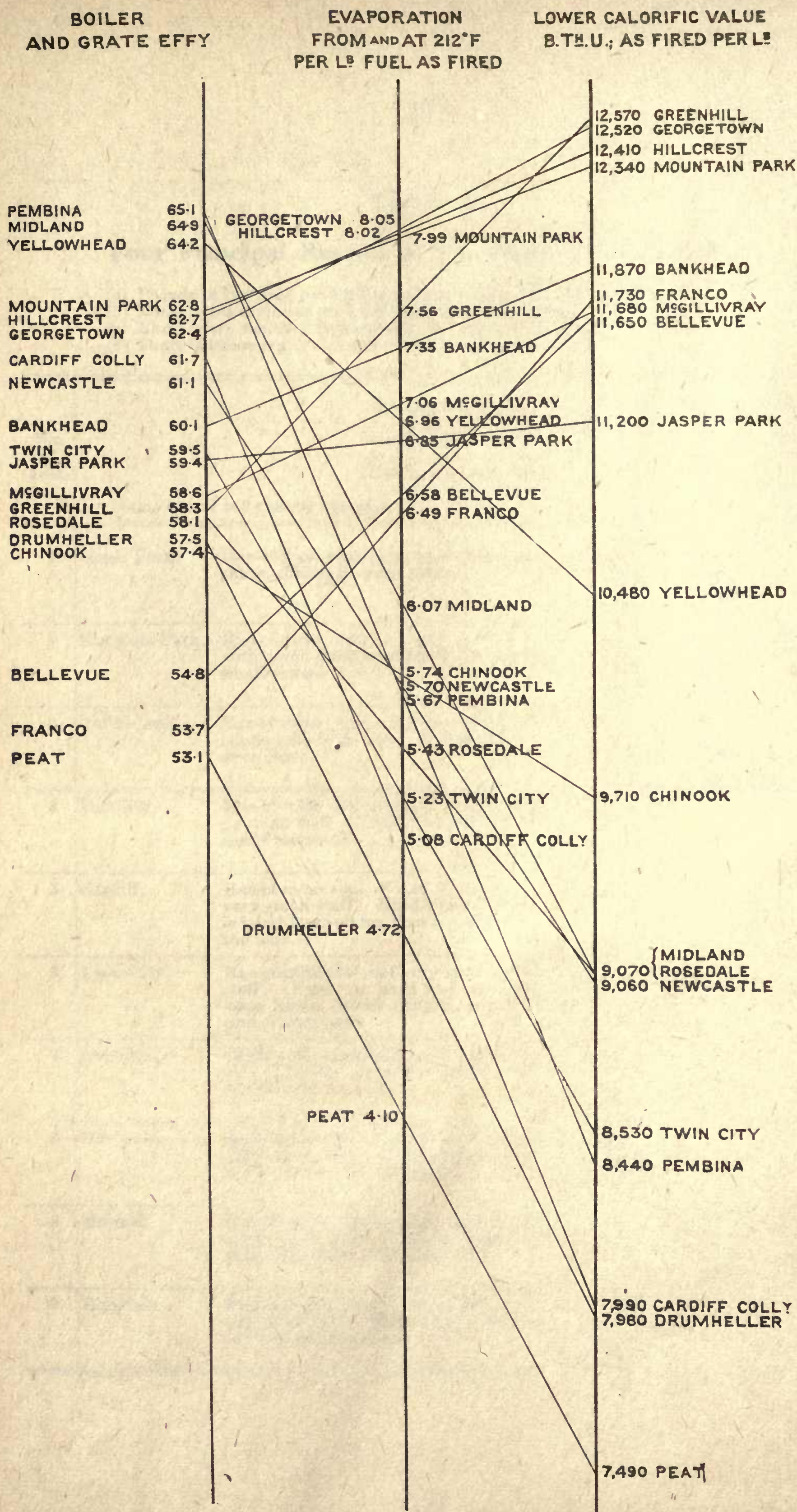

FIG. 1.—Chart showing the relation between the evaporation and calorific value per pound of fuel, and the thermal efficiency of the boiler and grate.

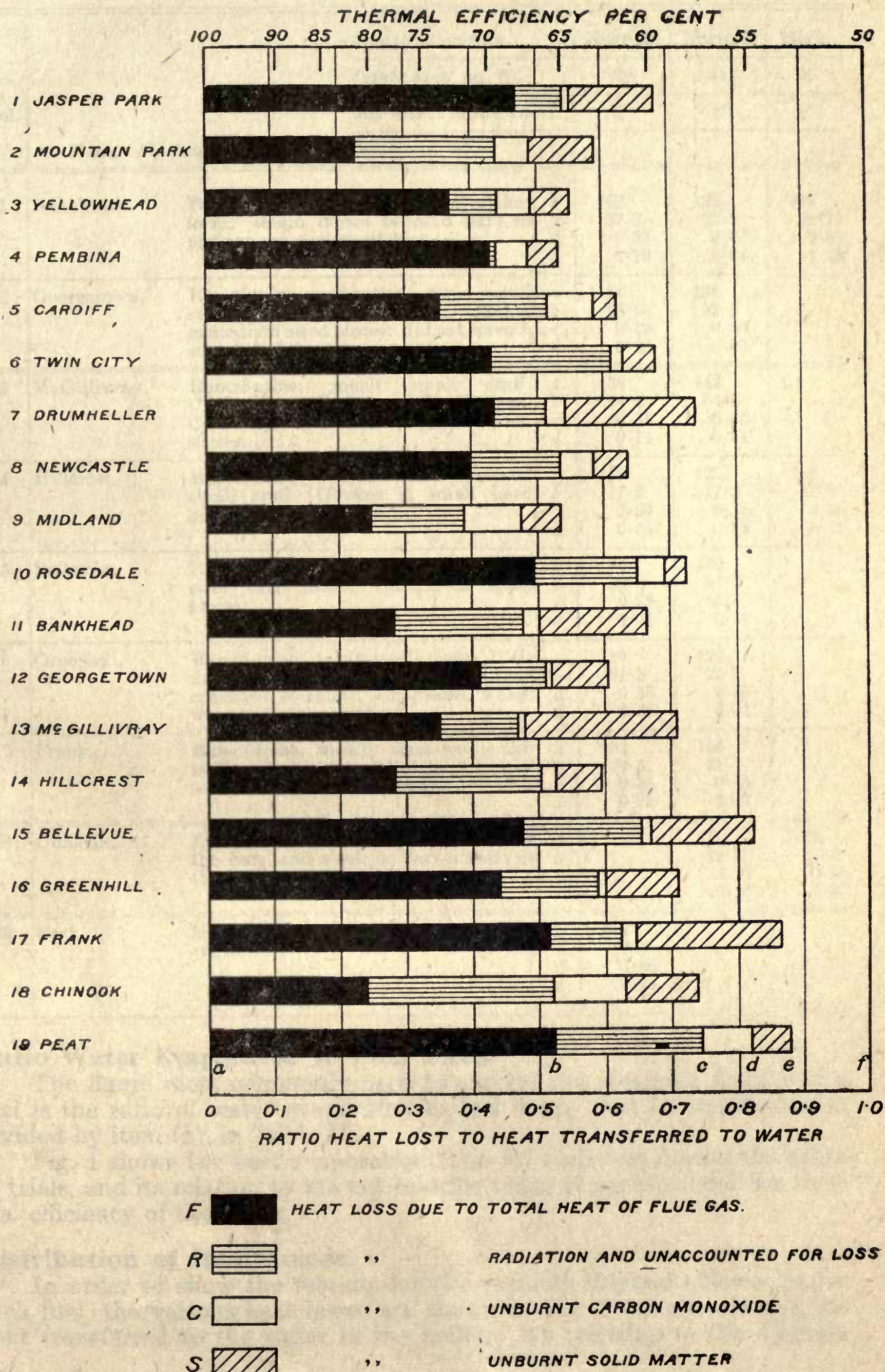

FIG. 2.—Chart showing the distribution of the heat losses as a fraction of the heat used for steam-raising.

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No. of Fuel.	Name of fuel and general remarks.		Evaporation rate, Grate area: sq. ft., Air spaces in fire bars,	Normal. 23 ¼″	Normal. 21 ½″	High. 21 ½″
11	Bankhead,	Pea anthracite. Large pieces of clinker form; steam blown beneath bars to prevent the clinker sticking.	a b c d	142 37·8 0·95 0·79	136 23·8 0·47 0·64	144 29·1 0·54 1·32
12	Georgetown,	Run-of-mine anthracite, very small stuff with some large pieces. Clinker in medium sized pieces; did not spread; sticks slightly to bars.	a b c d	124 18·6 0·79 0·68	136 31·8 0·36 0·59	
13	McGillivray,	Run-of-mine, much small stuff. Clinker in small pieces easily removed. Coal caked, necessitating frequent slicing.	a b c d	156 34·3 0·85 0·74	142 34·0 0·46 0·54	
14	Hillcrest,	Run-of-mine, contains much dust and small stuff. Clinker in small hard pieces. Coal cakes.	a b c d	125 17·2 0·89 0·54	125 17·0 0·18 0·28	130 17·7 0·26 0·85
15	Bellevue,	Run-of-mine, from medium to small size. Coal cakes. Clinker in small pieces.	a b c d	165 35·0 0·88 0·71	152 33·7 0·45 0·69	
16	Greenhill,	Run-of-mine; fairly small pieces, little dust. Refuse from above the bars consisted of small, soft pieces, which were easily removed.	a b c d	136 21·3 0·85 0·67	132 23·5 0·63 0·57	
17	Frank,	Run-of-mine, mostly dust and small stuff. Coal cakes. Refuse in small soft pieces, easily removed.	a b c d	162 38·5 0·86 0·76	154 41·7 0·40 0·87	
18	Chinook,	Lump coal. A thin clinker spread over the bars, and stuck to bars a little at the high rate of steaming.	a b c d	....	174 29·2 0·56 0·20	182 24·4 0·61 0·69
19	Peat,	Machine peat. No trouble from clinker.	a b c d	244 12·6 0·86 0·71		

Ratio Water Evaporated to Fuel Fired.

The figure most commonly used to express the steaming quality of a fuel is the ratio of water evaporated to fuel fired; that is, one thousand, divided by item (a), in Table II.

Fig. 1 shows the best evaporation ratio for each fuel during the series of trials, and its relation to the net calorific value of the fuel, and the thermal efficiency of the boiler.

Distribution of Heat Losses.

In order to show the reasons for the variable thermal efficiencies for each fuel, the various heat losses are shown in Fig. 2—as a fraction of the heat transferred to the water in the boiler. By referring to the diagram

for the peat—(fuel 19, Fig. 2)—it will be seen that the distance ae (ae = F+R+C+S) represents the total heat loss to the same scale that af (equal to unity on the lower scale) represents the heat used for steam-raising, The efficiency is equal to the ratio $\frac{af}{af+ae}$ and, putting af equal to unity, to $\frac{1}{1+ae}$; thus the efficiency—when we have a ratio of heat lost to heat used of 0·88—will be $\frac{1}{1+0\cdot88} = 0\cdot53$, or 53 per cent. Using similar calculations to this, a scale showing the efficiency corresponding to the heat losses has been placed at the top of the diagram. It is possible, by using the upper scale, to compare the different efficiencies; thus the efficiency corresponding to the loss represented by ad or (F+R+C) will be the ratio of the heat used to the heat supplied—excluding that which has been lost as unburnt solid matter (S); or the efficiency based on solid combustible consumed. Similarly, the efficiency corresponding to the loss ab or F, will be the ratio of the heat used to the total heat developed by combustion exclusive of that portion of the heat wasted as a radiation loss.

Loss due to High Temperature of Escaping Flue Gases.

The principal heat loss in the series of trials is that due to the total heat of the flue gas as indicated on the chart in Fig. 2. This loss (F), does not include that due to the uncondensed steam, and is therefore equal to C_p $(T_1—T_2)$ per pound of flue gas: where C_p is the mean specific heat at constant pressure; T_1 the flue gas temperature; and T_2 the temperature of the entering air. The variation of the loss due to the escaping hot gases for approximately the same boiler output is due almost entirely to

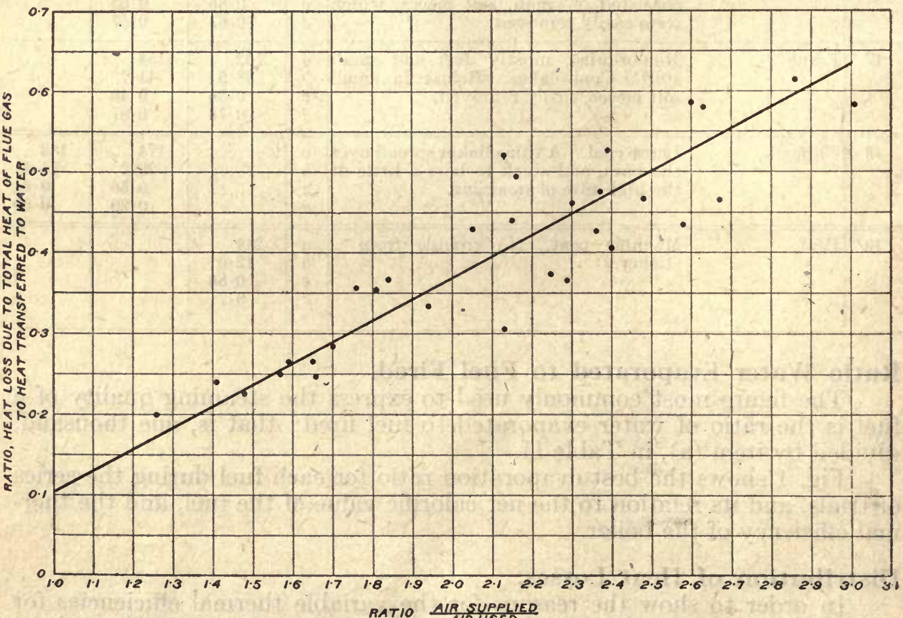


FIG. 3.—Diagram showing the relation between the loss due to the high temperature of the escaping flue gas and the air supply ratio.

the change in the amount of excess air: and Fig. 3 illustrates this by showing the relation between the ratio of the flue gas total heat loss to the heat usefully employed for steam-raising, and the ratio of the total air supplied to the air whose oxygen content is combined with the fuel. This air ratio is calculated from the flue gas analysis, and is equal to $\frac{21}{21-O_2.\frac{79}{N_2}}$ where O_2 and N_2 represent the volumes of oxygen and nitrogen in the flue gas, and $\frac{21}{79}$ the ratio of oxygen to nitrogen in the atmosphere. The expression $\frac{21}{100}\left[\frac{100+XL}{X(1+L)}\right]$ represents the ratio of air supplied to air required in terms of the carbon dioxide content of the flue gas (X) and the factor L, which depends upon the chemical constitution of the coal, and is equal to $\frac{3}{C}\left(H-\frac{O}{8}\right)$, where H, O, and C, represent the relative weights of the hydrogen, oxygen, and carbon contents of the fuel. This expression holds good only for complete combustion of a fuel whose sole constituents—which pass off with the flue gas—are carbon, hydrogen, and oxygen. The diagram in

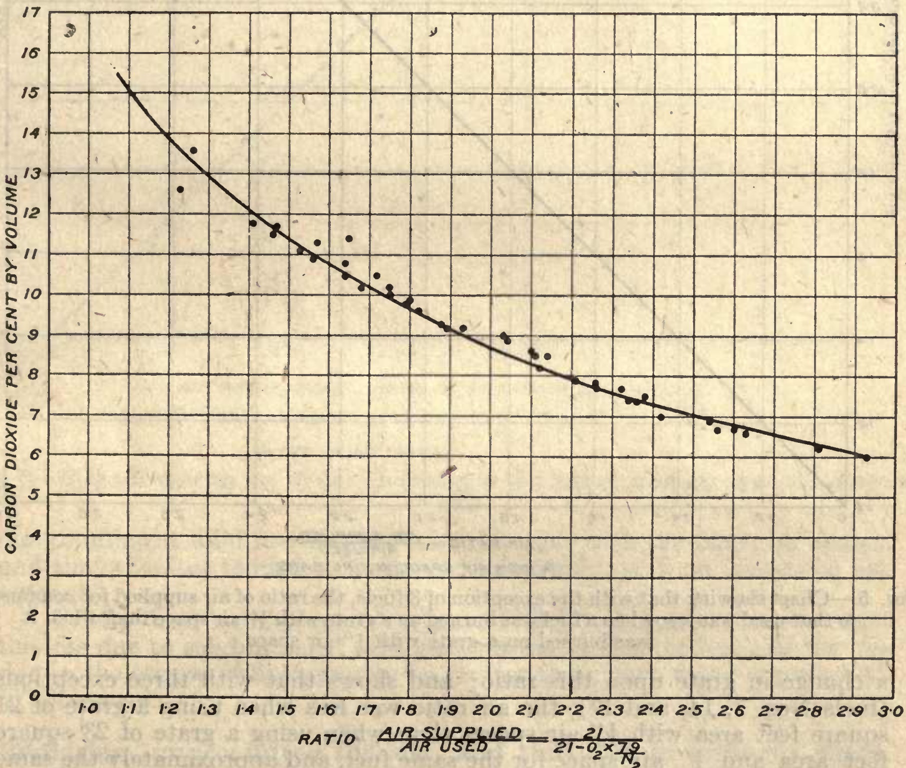


FIG. 4.—Diagram showing the relation between the average air ratios for the trials and the average carbon dioxide contents of the flue gas.

Fig. 4, shows the actual relation between the air ratio and the carbon dioxide content of the flue gas during the series of trials.

Variation in Excess Air.

Many factors, such as the chemical and physical characteristics of the fuel, and the form of furnace and grates, are responsible for the differences in the quantity of air used for combustion. Fig. 5 illustrates the effect of

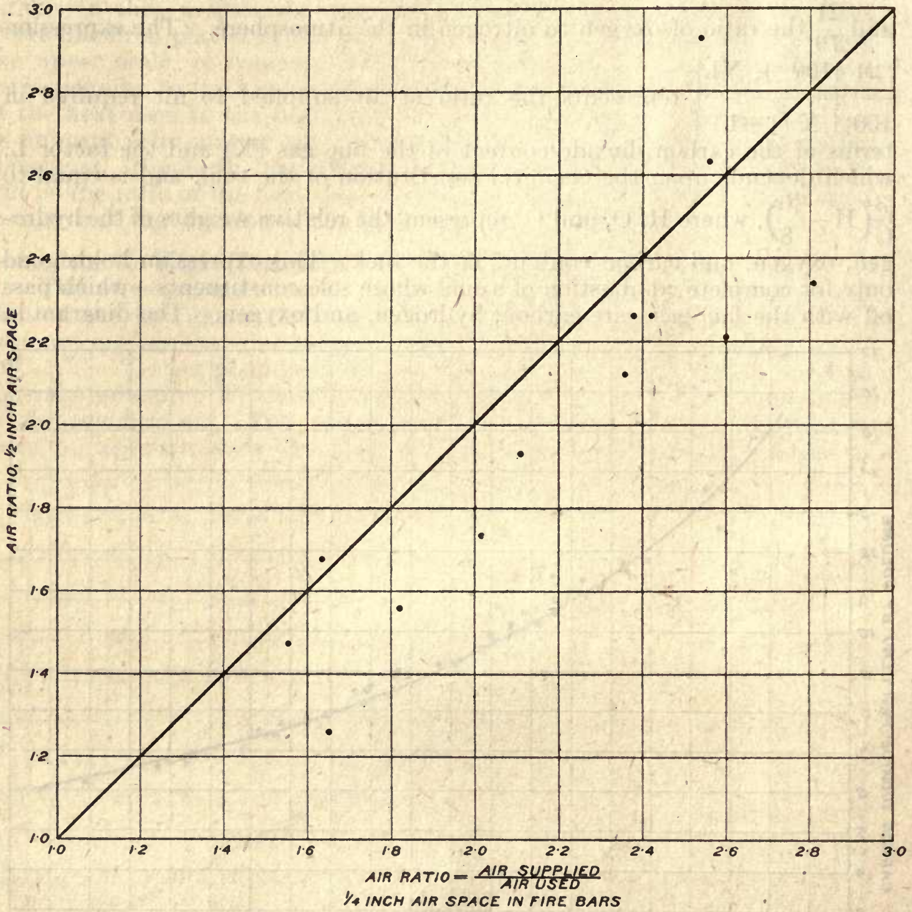


FIG. 5.—Chart showing that with the exception of 3 fuels, the ratio of air supplied for combustion to that used was less when a fuel was burned on a grate with ½″ air space than when it was burned on a grate with ¼″ air space.

a change in grate upon this ratio; and shows that with three exceptions (fuels Nos. 7, 14, and 17), the air ratio was less when using a grate of 21 square feet area with ½″ air spaces than when using a grate of 23 square feet area and ¼″ air space for the same fuel, and approximately the same rate of steaming. Fig. 6 shows that the excess air increased with an increase in the rate of combustion for four out of five coals.

While a change from the grate with small to one with larger air openings reduced the excess air loss, reference to Fig. 7 will show that the loss

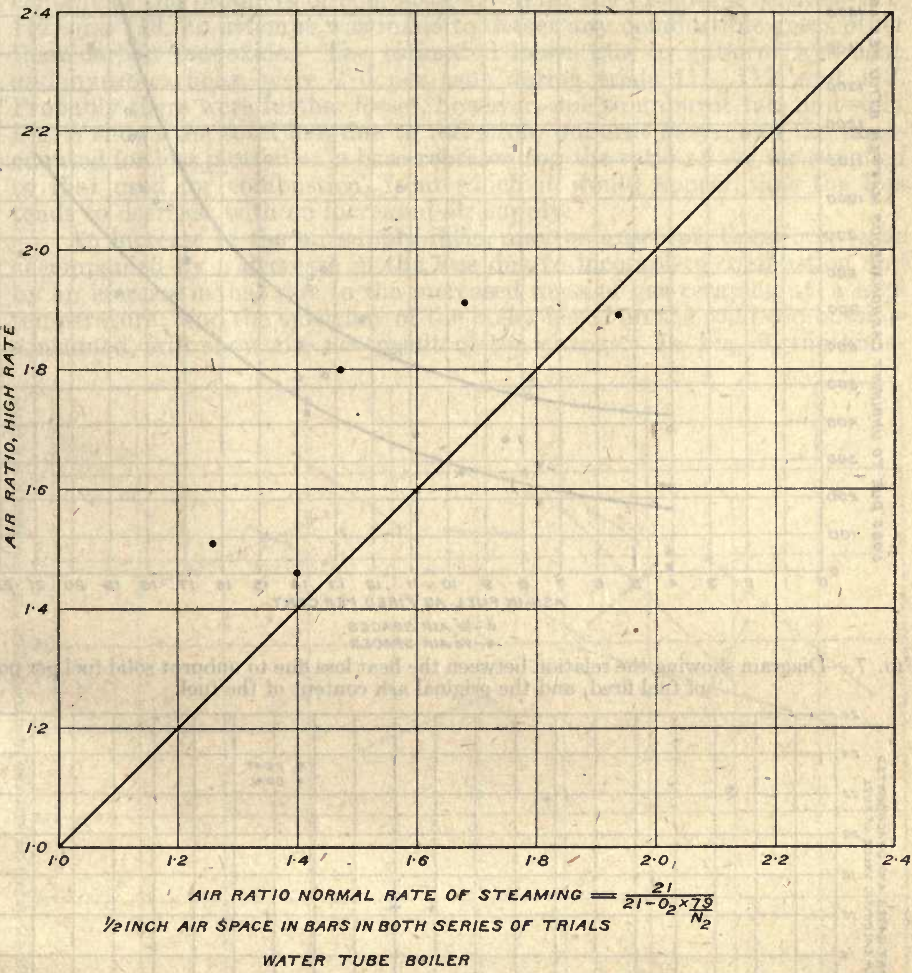


FIG. 6.—Diagram showing the effect of a change in the rate of steaming upon the excess air supply.

due to unburnt solid fuel increased for the trials with the larger air spaces, and that this loss tended to increase considerably, with an increasing ash content.

Briefly then, burning coal on a grate with $\frac{1}{4}''$ air spaces, tends to cause the loss due to solid unburnt carbonaceous material to be less and the loss due to the escape of flue gases to be greater than when using a grate with $\frac{1}{2}''$ air spaces.

Radiation, unaccounted for loss, and that due to unburnt gases.

The principal reasons for the variation in the radiation, and unaccounted for loss, where the rate of steaming remains the same, are variation

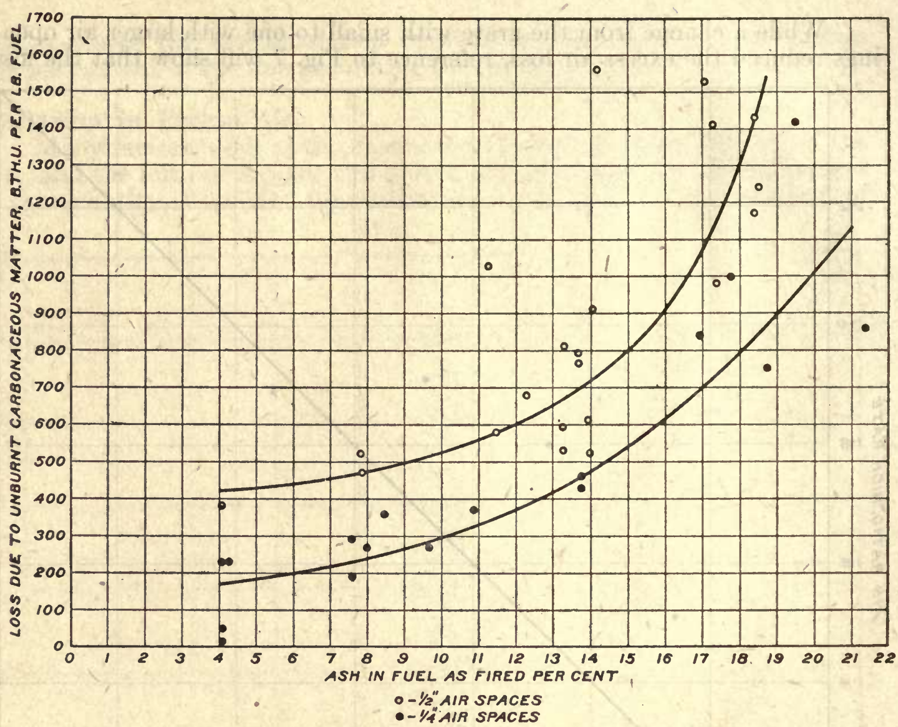


FIG. 7.—Diagram showing the relation between the heat loss due to unburnt solid fuel per pound of fuel fired, and the original ash content of the fuel.

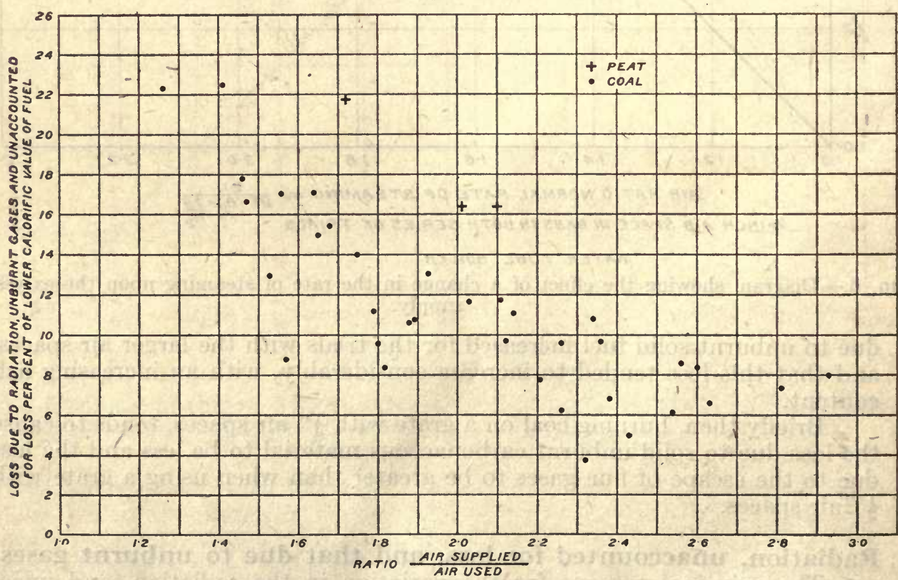


FIG. 8.—Diagram showing the relation which the sum of the percentage unaccounted for losses, and those due to radiation and unburnt gases bear to the air ratio.

in the heat transmitted from the hot gases and incandescent fuel through the boiler setting, and in the variation of the undetermined combustible content of the products of combustion. With the exception of trials 111, 112, and 113, no attempt was made to detect any combustible gases other than carbon monoxide. The estimated losses due to unburnt hydrogen and hydro-carbons, were 2·0 per cent during trials 111, 112, and 113. Probably there were further losses, however, due to unburnt tars and soot. Fig. 8 shows the total loss due to radiation, unburnt gases, and the unaccounted for loss plotted on a base representing the ratio of the air supplied to that used for combustion, from which it would appear that the loss tends to decrease with an increased air supply.

An increase in the air supply ratio, may be expected, therefore, to be accompanied by a decrease in the loss due to incomplete combustion and by an increase in that due to the increased mass of gas escaping at a high temperature; and the efficiency of the boiler based on the solid combustible consumed, will show the net result of the change. In Fig. 9, the boiler

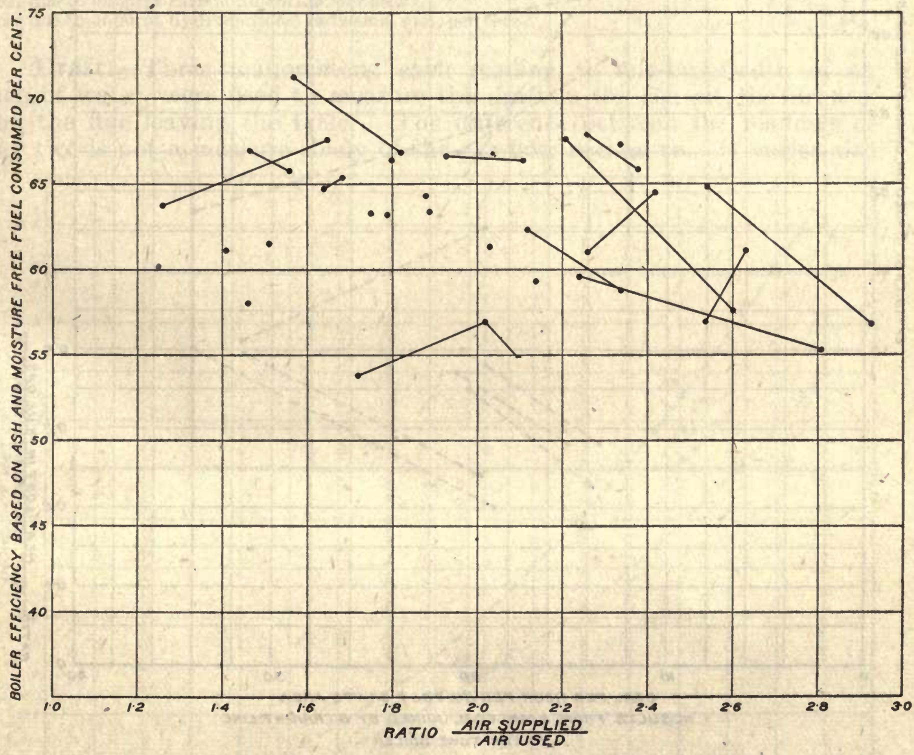


FIG. 9.—Diagram showing the boiler efficiencies at normal evaporation rates on a base representing the air ratio. Trials with the same fuel, are joined by straight lines.

efficiencies for the various trials are plotted on a base representing the excess air ratio; points in this chart obtained from trials on the same fuel are joined by lines.

Examination of this chart shows that while the predominant effect of increasing the air ratio for any particular fuel is to lower the efficiency, nevertheless there are many exceptions.

It should be remembered that the " radiation and unaccounted for loss " is not measured directly, but is found by subtracting the known losses from the heat energy of the fuel not used in steam-raising; and therefore varies with any error in measurement or sampling during the trial. These errors may be all of the same sign, when this loss will be either much too high or too low, as in trial 55 where the loss is only 0·7 per cent of the heat of the fuel.

Effect of rate of steaming on efficiency.

When sufficient fuel was available for an additional trial, it was burnt on the grate with $\frac{1}{2}$-inch air space, at a comparatively high rate of steaming.

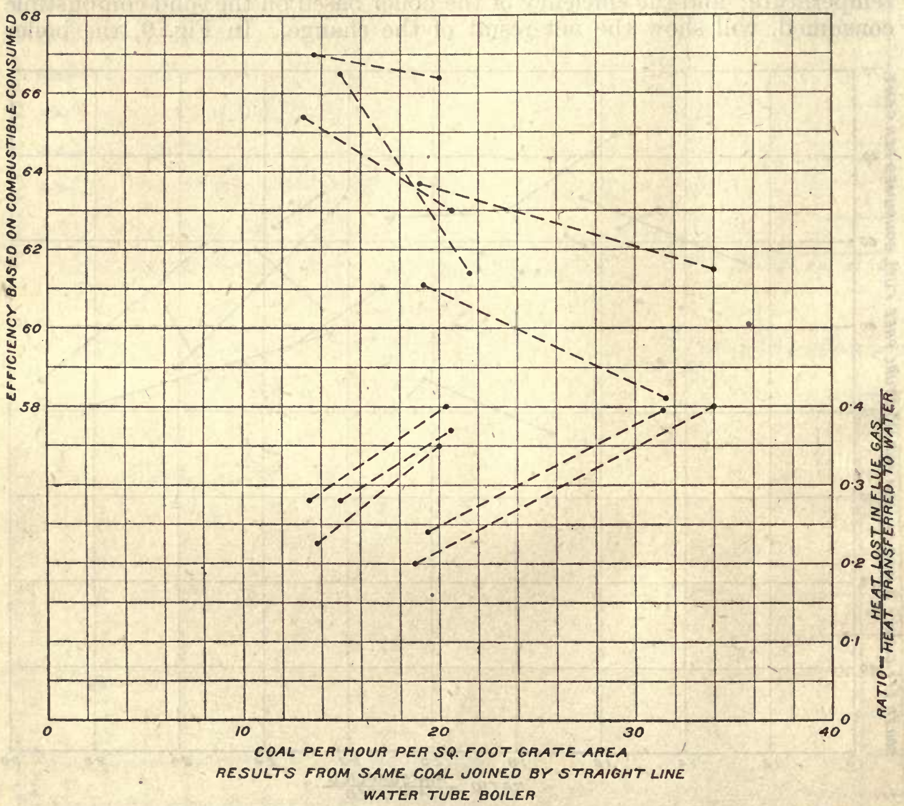


FIG. 10.—Diagram showing the decrease in thermal efficiency based on ash and moisture free fuel consumed and the increase in the loss due to the high temperature of the flue gas, with an increase in the rate of combustion.

Fig. 10 shows the relation between the efficiency based upon the ash and moisture free fuel consumed, and the rate of combustion; the efficiency is shown to decrease with the increased rate, and this decrease is due principally to the increased flue gas loss, which is shown in the same diagram.

This variation in the flue gas loss may be ascribed for the most part to the inability of the boiler heating surface to deal as efficiently with the larger gas flow, permitting the gases to leave the boiler at a higher temperature. That the excess air was generally greater when steaming at the higher rate has been referred to already—(see Fig. 6). The decrease in the efficiency with an increase in the combustion rate was very small when burning Mountain Park coal; the heat balance based on the lower calorific value of the coal shows this to be due to the closer attainment of complete combustion offsetting the loss due to the hot flue gas, as shown in the following table:—

Fuel	Mountain Park.	
Fuel, per hour per square foot of grate surface, lbs	13·5	20·0
Air ratio	1·47	1·80
Flue gas temperature, ° F	590	720
Thermal efficiency, per cent	62·8	62·2
Loss due to total heat of flue gas, per cent	14·3	21·8
Loss due to carbonaceous matter in ash and refuse, per cent	6·2	6·4
Loss due to unburnt carbon monoxide, per cent	3·2	1·1
Loss due to unburnt hydrocarbons, radiation, etc., per cent	13·5	8·5

Draft.—Three manometers, each reading to one-hundredth of an inch of water, were used to measure the draft in the ash-pit, the furnace, and the flue leaving the boiler. The difference between the readings of any two is not a measure solely of the gas flow resistance. It varies also

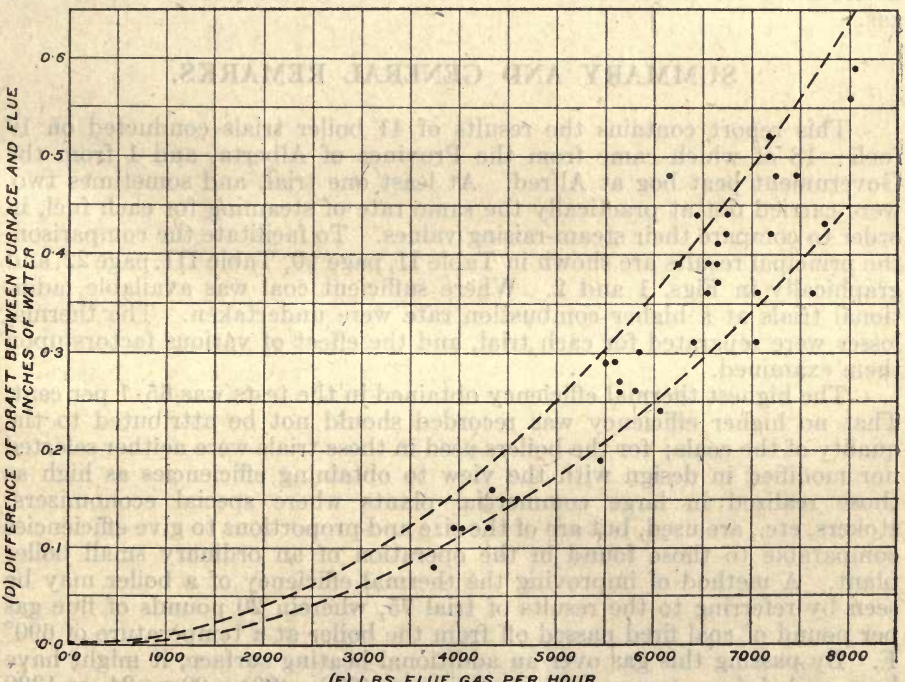


FIG. 11.—Diagram showing the relation between the difference of draft in the furnace and flue and the mass flow of the gases.

with the change in velocity of the gases; the vertical distance between the two places of measurement; and the mean density of the air in the boiler room and the gases inside the boiler setting. But the corrections for velocity head, differences in height of the gauges, and of density of the air and gases, are not very great, and for the same boiler working at the same rate are fairly constant. For this reason, it is permissible to consider the difference between the readings of two manometers as the resistance to the flow of gases between two sections of the boiler.

The resistance to the flow of air through the fuel bed depends upon the rate of gas flow and the general condition of the fire. Its accurate measurement and observation during operation is of great assistance in avoiding an excessive air supply due to poor firing, and shows the necessity for cleaning, breaking up a caking coal, or other operation to reduce the draft. But the characteristics of the various coals used during this series of trials were so different that it is impossible to show any general relation between fuel bed resistance and rate of combustion.

The resistance to the flow of gases from the furnace to the flue depends principally upon the mass flow of the gases. The relation between the gas flow and difference of draft, as measured during the trials at the furnace and flue, is shown in Fig. 11. It is important, since it shows that a simple differential draft gauge connected to the flue and furnace, in conjunction with a thermometer placed in the flue, will give an approximate means of determining the rate of heat loss due to the high temperature of the flue gas.

SUMMARY AND GENERAL REMARKS.

This report contains the results of 41 boiler trials conducted on 19 fuels: 18 of which came from the Province of Alberta, and 1 from the Government peat bog at Alfred. At least one trial, and sometimes two, were carried out at practically the same rate of steaming for each fuel, in order to compare their steam-raising values. To facilitate the comparison, the principal results are shown in Table II, page 10, Table III, page 22, and graphically in Figs. 1 and 2. Where sufficient coal was available, additional trials at a higher combustion rate were undertaken. The thermal losses were separated for each trial, and the effect of various factors upon them examined.

The highest thermal efficiency obtained in the tests was 65·1 per cent. That no higher efficiency was recorded should not be attributed to the quality of the coals; for the boilers used in these trials were neither selected nor modified in design with the view to obtaining efficiencies as high as those realized in large commercial plants where special economizers, stokers, etc., are used, but are of the size and proportions to give efficiencies comparable to those found in the operation of an ordinary small boiler plant. A method of improving the thermal efficiency of a boiler may be seen by referring to the results of trial 75, wherein 20 pounds of flue gas per pound of coal fired passed off from the boiler at a temperature of 690° F. By passing this gas over an additional heating surface, it might have been cooled down to say 400° F., giving up (690 − 400) x 20 x ·24, or 1390 British thermal heat units per pound of coal fired, which would mean an additional evaporation from and at 212° F., of 1390 ÷ 970·7, or 1·4 pounds of steam per pound of coal, and have increased the efficiency by 11·8 per

cent. By still further increasing the heating surface, or by using means to cause the gases to more thoroughly scrub the heating surface already in existence, the flue gas temperature could be lowered nearer and nearer to the temperature of the external walls of the boiler heating surface (about 340° F.), while the addition of an economizer would render still more heat available for warming the feed water before entering the boiler.

TABLE III.

Short General Report of Trials.

1	2	3	4	5	6	7	8	9
No. of Fuel.	No. of Trial.	Name of Fuel.	Area of Grate. Sq. ft.	Lb. Steam per hour.	Lb. fuel per sq. ft. grate area per hour.	Evaporation from and at per lb. fuel as fired. Lb.	Boiler and grate efficiency. Per cent.	Grate efficiency. Per cent.
1	59	Jasper Park.......	23	2,220	14·0	6·85	59·4	93·6
	75	"	21	2,130	15·5	6·61	54·6	90·1
2	113	Mountain Park....	23	2,240	12·2	7·99	63·5	97·0
	107	"	21	2,270	13·5	7·99	62·8	94·3
	108	"	21	3,330	20·0	7·91	62·2	95·3
3	60	Yellowhead Pass..	23	2,450	15·2	6·96	64·4	97·3
	74	" ..	21	2,210	15·4	6·90	64·2	92·7
4	55	Pembina..........	23	2,456	18·7	5·67	65·1	97·3
5	52	Cardiff...........	23	2,404	20·4	5·08	61·7	97·7
6	53	Twin City.........	23	2,427	20·0	5·23	59·5	97·0
7	58	Drumheller.......	23	1,911	17·4	4·72	57·5	88·5
	76	"	21	1,530	19·8	3·71	45·6	80·9
8	61	Newcastle.........	23	2,333	17·6	5·70	61·1	96·8
9	111	Midland..........	23	2,300	16·5	6·07	64·9	96·1
	103	"	21	2,270	18·9	5·71	60·5	94·9
	102	"	21	3,910	34·0	5·47	58·0	95·2
10	51	Rosedale..........	23	2,554	20·2	5·43	58·1	98·1
11	114	Bankhead.........	23	2,230	13·8	7·04	58·3	89·0
	109	"	21	2,290	14·9	7·35	60·1	93·4
	110	"	21	3,100	21·3	6·93	56·6	91·2
12	54	Georgetown.......	23	2,377	12·7	8·05	62·4	95·2
	77	"	21	2,130	13·9	7·35	57·0	84·1
13	69	McGillivray.......	23	1,805	12·2	6·39	53·4	93·0
	78	"	21	2,080	14·2	7·06	58·6	88·6
14	112	Hillcrest..........	23	2,280	12·4	7·99	62·5	97·0
	105	"	21	2,220	13·1	8·02	62·7	96·7
	106	"	21	3,320	20·5	7·70	60·2	96·3
15	67	Bellevue...........	23	1,880	13·4	6·05	51·7	94·2
	80	"	21	2,060	15·0	6·58	54·8	92·3
16	68	Greenhill..........	23	2,006	11·8	7·33	56·1	95·4
	81	"	21	2,250	14·3	7·56	58·3	94·0
17	70	Frank.............	23	1,802	12·6	6·16	52·1	91·7
	79	"	21	2,055	15·2	6·49	53·7	87·9
18	100	Chinook...........	21	2,310	19·1	5·74	57·4	94·2
	101	"	21	3,620	31·4	5·49	54·9	95·7
19	71	Peat..............	23	1,950	20·5	4·10	53·1	97·1
	72	"	38	2,322	15·5	3·96	51·3	96·4
	73	"	38	2,250	15·0	3·95	54·8	97·8
	83	Peat, using small fire tube boiler.	9	621	17·7	3·89	52·9	99·8
	84		9	802	23·8	3·74	52·1	99·7
	85		9	1,054	37·9	3·09	42·2	99·6

TABLE III—*Concluded.*

Short General Report of Trials—*Continued.*

10	11	12	13	14	15	16	17
Efficiency combustible consumed. Per cent.	Ratio air supplied to air used for combustion.	Carbon dioxide, per cent.	Ratio flue gas loss to heat used for steam generation.	Flue gas, Temp. °F.	Net calorific value fuel as fired. B.Th.U. per lb.	Ash, per cent.	Moisture, per cent.
64·5	2·43	7·0	·471	660	11,200	21·4	2·3
61·0	2·26	7·7	·464	690	11,760	18·5	1·4
65·8	1·56	10·9	·251	590	12,220	13·8	2·8
67·0	1·47	11·7	·228	590	12,340	13·7	2·2
66·4	1·80	9·9	·351	720	12,340	13·7	2·2
66·9	1·82	9·6	·367	730	10,480	10·9	5·9
71·2	1·57	11·3	·267	680	10,430	11·3	5·9
67·4	2·32	7·7	·427	645	8,440	9·7	17·0
63·2	1·75	10·2	·355	670	7,990	7·6	21·2
61·4	2·03	9·0	·430	690	8,530	8·0	18·0
64·9	2·54	6·9	·434	580	7,980	14·1	18·3
56·8	2·93	6·0	·586	600	7,900	14·2	18·8
63·1	1·79	9·8	·402	730	9,060	7·6	16·5
67·6	1·65	11·4	·248	580	9,070	8·5	16·3
63·8	1·26	13·6	·200	560	9,160	7·9	16·2
61·5	1·51	11·1	·401	840	9,160	7·9	16·2
59·4	2·14	8·5	·493	730	9,070	7·6	15·3
66·3	2·11	8·5	·306	540	11,720	19·5	1·0
66·6	1·93	9·2	·282	550	11,870	18·4	1·1
64·4	1·88	9·3	·363	680	11,870	18·4	1·1
65·9	2·38	7·5	·407	630	12,520	12·3	2·9
67·9	2·26	7·8	·366	620	12,510	13·2	2·1
57·6	2·60	6·7	·581	710	11,620	17·0	2·5
67·6	2·21	7·9	·348	610	11,680	17·1	2·0
64·9	1·64	10·8	·268	610	12,400	13·8	2·0
65·4	1·68	10·2	·283	610	12,410	14·0	1·9
63·4	1·89	9·2	·400	740	12,410	14·0	1·9
55·2	2·81	6·2	·663	705	11,360	18·8	2·7
59·6	2·34	7·4	·473	670	11,650	17·4	2·1
58·8	2·36	7·4	·528	720	12,700	11·5	2·5
62·4	2·12	8·2	·439	710	12,570	13·3	1·6
57·0	2·56	6·7	·588	720	11,490	17·8	2·8
61·1	2·63	6·6	·516	670	11,730	17·3	1·7
61·1	1·41	11·8	·244	580	9,710	13·3	9·8
58·1	1·46	11·5	·398	840	9,710	13·3	9·8
54·9	2·10	8·6	·513	720	7,490	4·1	15·7
53·9	1·72	10·5	·453	760	7,490	4·1	15·7
56·8	2·02	8·9	·463	715	6,990	4·3	20·3
53·0	1·74	10·0	·429	690	7,130	4·1	19·2
52·5	1·63	10·5	·414	690	6,970	4·7	20·1
42·5	1·24	12·6	·410	750	7,110	4·2	19·2

TABLE IV.

Detailed Report of Trials.

General Particulars of Trial.						Description of Boiler.									
							Description of Grate.						Heating surface.		
No. of Trial.	Name of Fuel.	Date when fuel was received.	Date of the trial.	Duration.	Rate of steaming.	Boiler.	Type of bars.	Width.	Length.	Area.	Air space.	Ratio air space to total area.	Tubes.	Total.	Ratio heating surface to grate surface.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
				h. m.	lb. per h.			ft. in.	ft. in.	sq. ft.	inches.	per cent.	sq. ft.	sq. ft.	
59	Jasper Park	Jan. 19, 1915	Feb. 1, 1915	12 0	1,900	Water tube.	Corrugated.	4 9½	4 10	23·2	0·25	30	633	677	29
75	"	" 19, 1915	June 22, 1915	10 6	1,900	"	Plain	4 4½	4 9	20·8	0·50	50	633	677	32·5
113	Mountain Park	May 17, 1916	Dec. 14, 1916	11 0	1,960	"	Corrugated.	4 9½	4 10	23·2	0·25	30	633	677	29
107	"	" 17, 1916	Nov. 28, 1916	10 2	1,960	"	Plain	4 4½	4 9	20·8	0·5	50	633	677	32·5
108	"	" 17, 1916	" 30, 1916	6 0	2,800	"	"	4 4½	4 9	20·8	0·5	50	633	677	32·5
60	Yellowhead Pass	May 27, 1914	Feb. 3, 1915	12 0	2,000	"	Corrugated.	4 9½	4 10	23·2	0·25	30	633	677	29
74	"	" 27, 1914	June 17, 1915	12 10	2,000	"	Plain	4 4½	4 9	20·8	0·5	50	633	677	32·5
55	Pembina		Mar. 27, 1914	12 0	2,030	"	Corrugated.	4 9½	4 10	23·2	0·25	30	633	677	29
52	Cardiff	Aug. 29, 1912	Mar. 20, 1914	12 0	1,980	"	Corrugated.	4 9½	4 10	23·2	0·25	30	633	677	29
53	Twin City	Aug. 30, 1912	Mar. 23, 1914	12 0	2,000	"	Corrugated.	4 9½	4 10	23·2	0·25	30	633	677	29
58	Drumheller	June 10, 1914	Jan. 28, 1915	11 55	1,600	"	Corrugated.	4 9½	4 10	23·2	0·25	30	633	677	29
76	"	" 10, 1914	June 24, 1915	10 17	1,350	"	Plain	4 4½	4 9	20·8	0·5	50	633	677	32·5
61	Newcastle	Oct. 17, 1914	Feb. 5, 1915	12 0	2,000	"	Corrugated.	4 9½	4 10	23·2	0·25	30	633	677	29
111	Midland	Sept. 30, 1915	Dec. 11, 1916	10 59	1,980	"	Corrugated.	4 9½	4 10	23·2	0·25	30	633	677	29
103	"	" 30, 1915	Nov. 21, 1916	10 0	1,970	"	Plain	4 4½	4 9	20·8	0·5	50	633	677	32·5
102	"	" 30, 1915	Nov. 20, 1916	5 57	3,200	"	"	4 4½	4 9	20·8	0·5	50	633	677	32·5
51	Rosedale	Dec. 18, 1912	Mar. 18, 1914	12 0	2,100	"	Corrugated.	4 9½	4 10	23·2	0·25	30	633	677	29

114	Bankhead	June 6, 1916	Dec. 15, 1916	10 59	1,950	"	Corrugated	4 9½	4 10	23·2	0·25	30	633	677	29
109	"	" 6, 1916	" 1, 1916	10 6	1,980	"	Plain	4 4½	4 9	20·8	0·5	50	633	677	32·5
110	"	" 6, 1916	" 4, 1916	6 2	2,620	"	"	4 4½	4 9	20·8	0·5	50	633	677	32·5
54	Georgetown	Dec. 5, 1913	Mar. 25, 1914	12 0	1,960	"	Corrugated	4 9½	4 10	23·2	0·25	30	633	677	29
77	"	" 5, 1913	June 29, 1915	9 54	1,800	"	Plain	4 4½	4 9	20·8	0·5	50	633	677	32·5
69	McGillivray	May 13, 1914	April 20, 1915	11 54	1,600	"	Corrugated	4 9½	4 10	23·2	0·25	30	633	677	29
78	"	" 13, 1914	June 30, 1915	9 51	1,850	"	Plain	4 4½	4 9	20·8	0·5	50	633	677	32·5
112	Hillcrest seam No. 1	Jan. 5, 1916	Dec. 12, 1916	11 0	1,970	"	Corrugated	4 9½	4 10	23·2	0·25	30	633	677	29
105	" "	" 5, 1916	Nov. 24, 1916	10 5	1,900	"	Plain	4 4½	4 9	20·8	0·5	50	633	677	32·5
106	" "	" 5, 1916	" 27, 1916	6 1	2,800	"	"	4 4½	4 9	20·8	0·5	50	633	677	32·5
67	Bellevue	Nov. 19, 1914	April 13, 1915	11 58	1,650	"	Corrugated	4 9½	4 10	23·2	0·25	30	633	677	29
80	"	" 19, 1914	July 14, 1915	10 7	1,800	"	Plain	4 4½	4 9	20·8	0·5	50	633	677	32·5
68	Greenhill	Mar. 1, 1915	April 15, 1915	12 0	1,800	"	Corrugated	4 9½	4 10	23·2	0·25	30	633	677	29
81	"	" 1, 1915	July 16, 1915	9 58	2,000	"	Plain	4 4½	4 9	20·8	0·5	50	633	677	32·5
70	Frank	Nov. 24, 1914	April 22, 1915	11 51	1,600	"	Corrugated	4 9½	4 10	23·2	0·25	30	633	677	29
79	"	" 24, 1914	July 7, 1915	9 57	1,830	"	Plain	4 4½	4 9	20·8	0·5	50	633	677	32·5
100	Chinook	Oct. 18, 1915	Nov. 15, 1916	9 58	1,900	"	Plain	4 4½	4 9	20·8	0·5	50	633	677	32·5
101	"	" 18, 1915	" 16, 1916	5 58	3,000	"	"	4 4½	4 9	20·8	0·5	50	633	677	32·5
71	Machine peat from Alfred, Ont.		May 18, 1915	9 48	1,740	"	Corrugated	4 9½	4 10	23·2	0·25	30	633	677	29
72	" "		" 26, 1915	9 58	2,060	"	Plain	6 9½	5 7	37·9	0·5	50	633	677	18
73	" "		June 1, 1915	10 0	1,990	"	Corrugated	6 9½	5 7	37·9	0·25	30	633	677	18
83	" "		Oct. 1, 1915	7 58	530	Locomotive	Plain	3 0	3 0	9	0·25	31	168	215	24
84	" "		" 5, 1915	8 0	690	"	"	3 0	3 0	9	0·25	31	168	215	24
85	" "		" 26, 1915	7 58	900	"	"	3 0	3 0	9	0·25	31	168	215	24

TABLE IV.

Detailed Report of Trials—*Continued.*

No. of Trial.	Name of Fuel.	Thickness of fire.	Size.	Particulars of the Fuel. Analysis (by weight) as fired. Ultimate. Carbon.	Hydrogen.	Ash.	Sulphur	Oxygen and nitrogen	Proximate. Fixed carbon (F.C.)	Volatile matter (V.M.)	Ash.	Moisture.	Fuel Ratio F.C./V.M.	Calorific value of fuel per lb. As fired. Gross.	As fired. Net.	Dry Gross.	Combustible Gross.
2	17		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
		inches.		per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.		B. Th.U.	B. Th.U.	B. Th.U.	B. Th. U.
59	Jasper Park........	10	Run-of-mine lump to dust.	66·8	4·0	21·4	0·8	7·0	57·8	18·5	21·4	2·3	3·12	11,580	11,200	11,840	15,170
75	"	7 to 8	" "	70·0	4·1	18·5	0·8	6·6	60·7	19·4	18·5	1·4	3·13	12,150	11,760	12,320	15,160
113	Mountain Park....	4½	Run-of-mine with much small stuff.	72·2	4·7	13·8	0·3	9·0	59·6	23·8	13·8	2·8	2·50	12,670	12,220	13,040	15,200
107.	"	4½	" "	72·8	4·6	13·7	0·4	8·5	60·0	24·1	13·7	2·2	2·50	12,780	12,340	13,070	15,200
108	"	4	" "	72·8	4·6	13·7	0·4	8·5	60·0	24·1	13·7	2·2	2·50	12,780	12,340	13,070	15,200
60	Yellowhead Pass..	6	Run-of-mine mostly 5" lump very little dust	64·5	4·7	10·9	0·2	19·7	48·0	35·2	10·9	5·9	1·36	10,930	10,480	11,620	13,140
74	" ..	6½	" "	64·1	4·7	11·3	0·2	19·7	47·8	35·0	11·3	5·9	1·37	10,880	10,430	11,560	13,140
55	Pembina..........	4 to 6	Run-of-mine 2" to 5" no small stuff.	54·4	5·7	9·7	0·2	30·0	43·8	29·5	9·7	17·0	1·48	8,980	8,440	10,830	12,250
52	Cardiff............	6	Run-of-mine varies 4" to 5" lumps to very small.	51·5	6·1	7·6	0·2	34·6	39·1	32·1	7·6	21·2	1·22	8,570	7,990	10,870	12,000

53	Twin City........	4	Run-of-mine not very much small stuff.	53·7	5·9	8·0	0·4	32·0	41·0	33·0	8·0	18·0	1·37	9,090	8,530	11,080	12,280
58	Drumheller........	5	Slack, contains much dust and dirt.	50·1	5·4	14·1	0·4	30·0	38·7	28·9	14·1	18·3	1·34	8,490	7,980	10,390	12,560
76	"	4	" "	49·6	5·5	14·2	0·4	30·3	38·4	28·6	14·2	18·8	1·34	8,420	7,900	10,360	12,570
61	Newcastle.........	5	Run-of-mine, 5" lump and smaller, very little dust.	56·3	5·6	7·6	0·4	30·1	43·8	32·1	7·6	16·5	1·35	9,590	9,060	11,500	12,640
111	Midland..........	4	Run-of-mine, fairly large lumps, little small stuff.	56·7	5·5	8·5	0·4	28·9	45·3	29·9	8·5	16·3	1·50	9,590	9,070	11,460	12,750
103	"	4	" "	57·3	5·5	7·9	0·4	28·9	45·6	30·3	7·9	16·2	1·50	9,680	9,160	11,560	12,760
102	"	5	" "	57·3	5·5	7·9	0·4	28·9	45·6	30·3	7·9	16·2	1·50	9,680	9,160	11,560	12,760
51	Rosedale..........	4½ to 5	Run-of-mine....	56·9	5·6	7·6	0·6	29·3	45·0	32·1	7·6	15·3	1·40	9,600	9,070	11,340	12,450
114	Bankhead.........	4	⅞ to 5/16........	71·8	3·3	19·5	0·4	5·0	69·7	9·8	19·5	1·0	7·10	12,030	11,720	12,150	15,120
109	"	5½	"	72·7	3·3	18·4	0·5	5·1	70·5	10·0	18·4	1·1	7·10	12,180	11,870	12,310	15,120
110	"	6	"	72·7	3·3	18·4	0·5	5·1	70·5	10·0	18·4	1·1	7·10	12,180	11,870	12,310	15,120
54	Georgetown.......	6 to 7	Run-of-mine, 5" very small stuff.	76·2	4·2	12·3	0·8	6·5	71·7	13·1	12·3	2·9	5·47	12,900	12,520	13,300	15,230
77	"	5	" "	76·1	4·1	13·2	0·8	5·8	71·6	13·1	13·2	2·1	5·47	12,900	12,510	13,170	15,240
69	McGillivray.......	8 to 9	Run-of-mine, much small stuff.	69·3	4·4	17·0	0·7	8·6	56·5	24·0	17·0	2·5	2·35	12,040	11,620	12,350	15,000
78	"	6 to 7	" "	69·6	4·4	17·1	0·7	8·2	56·8	24·1	17·1	2·0	2·36	12,100	11,680	12,350	15,000
112	Hillcrest, Seam No. 1	5	Run-of-mine....	72·2	4·5	13·8	0·6	8·9	59·0	25·2	13·8	2·0	2·35	12,830	12,400	13,090	15,240
105	" " ..	4½	"	72·1	4·5	14·0	0·6	8·8	58·9	25·2	14·0	1·9	2·35	12,840	12,410	13,060	15,260
106	" " ..	4½	" ...	72·1	4·5	14·0	0·6	8·8	58·9	25·2	14·0	1·9	2·35	12,840	12,410	13,060	15,260
67	Bellevue...........	8	Run-of-mine, medium to small	67·9	4·5	18·8	0·5	8·3	53·0	25·5	18·8	2·7	2·10	11,790	11,360	12,110	15,030
80	"	4	" "	69·6	4·5	17·4	0·6	7·9	54·4	26·1	17·4	2·1	2·10	12,080	11,650	12,350	15,010
68	Greenhill..........	8 to 10	Run-of-mine, fairly small, little dust.	75·3	4·6	11·5	0·6	8·0	61·1	24·9	11·5	2·5	2·45	13,140	12,700	13,470	15,280
81	"	4	" "	74·5	4·5	13·3	0·6	7·1	60·5	24·6	13·3	1·6	2·45	13,000	12,570	13,210	15,280
70	Frank.............	8	Run-of-mine, mostly dust & small stuff.	68·0	4·4	17·8	0·6	9·2	53·2	26·2	17·8	2·8	2·05	11,910	11,490	12,250	15,000
79	"	6	" "	69·4	4·4	17·3	0·6	8·3	54·2	26·8	17·3	1·7	2·05	12,150	11,730	12,360	15,000

TABLE IV.

Detailed Report of Trials—*Continued.*

No. of Trial.	Name of Fuel.	Thickness of fire.		Particulars of the Fuel. Analysis (by weight) as fired. Ultimate. Carbon.	Hydrogen.	Ash.	Sulphur	Oxygen and nitrogen	Proximate. Fixed carbon (F.C.)	Volatile matter (V.M.)	Ash.	Moisture.	Fuel Ratio F.C./V.M.	Calorific value of fuel per lb. As fired. Gross.	Net.	Dry Gross.	Combustible Gross.*
2	17		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
		inches.		per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.		B. Th.U.	B. Th.U.	B. Th.U.	B. Th.U.
100	Chinook..........	6	Lump coal......	58·7	5·3	13·3	0·7	22·0	45·5	31·4	13·3	9·8	1·45	10,210	9,710	11,320	13,280
101	"	6	" "	58·7	5·3	13·3	0·7	22·0	45·5	31·4	13·3	9·8	1·45	10,210	9,710	11,320	13,280
71	Machine peat from Alfred, Ont.	4 to 5	Small blocks, very little dust	47·0	6·1	4·1	0·1	42·7	25·6	54·6	4·1	15·7	0·47	8,070	7,490	9,570	10,060
72	" " ..	4 to 5	" "	47·0	6·1	4·1	0·1	42·7	25·6	54·6	4·1	15·7	0·47	8,070	7,490	9,570	10,060
73	" " ..	5	" "	44·2	6·3	4·3	0·1	45·1	24·1	51·3	4·3	20·3	0·47	7,590	6,990	9,520	10,060
83	" " ..	....	" "	45·0	6·3	4·1	.0·1	44·5	24·5	52·2	4·1	19·2	0·47	7,730	7,130	9,560	10,060
84	" " ..	....	" "	44·1	6·3	4·7	0·1	44·8	24·0	51·2	4·7	20·1	0·47	7,570	6,970	9,470	10,060
85	" " ..	....	" "	44·9	6·3	4·2	0·1	44·5	24·5	52·1	4·2	19·2	0·47	7,710	7,110	9,550	10,060

* "Combustible" means "Ash and Moisture Free Fuel."

TABLE IV.

Detailed Report of Trials—*Continued*

No. of Trial.	Name of Fuel.	Fuel, total quantities. Fuel fired. As fired.	Dry.	*Combustible. Fired.	Con-sumed.	Fuel fired per 1,000 lbs. water evaporated from and at 212° F.	Ash and Refuse. Refuse removed from Above fire bars.	Ash-pit.	Ash-pit and above fire bars.	*Combustible in refuse removed.	Calorific value of refuse per lb.	Total weight *combustible in refuse removed.	Weight of ash in Refuse.	Fuel fired.	Estimated weight of unconsumed *combustible	Ratio refuse removed from grate to total refuse removed.	Total refuse removed. Per cent of fuel fired.	Per 1,000 lb. steam from and at 212° F.
1	2	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
		lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	per cent.	B. Th.U.	lb.	lb.	lb.	lb.			lb.
59	Jasper Park.......	3,884	3,800	2,960	2,730	146	713	165	878	21·7	3,150	191	687	831	230	0·81	22·6	33·0
75	"	3,263	3,217	2,614	2,334	151	290	540	830	31·7	4,600	263	567	603	280	0·35	25·4	38·5
113	Mountain Park....	3,086	3,000	2,574	2,482	125	398	38	436	17·7	2,570	77	359	426	92	0·91	14·1	17·7
107	"	2,844	2,781	2,391	2,241	125	218	278	496	27·8	4,030	138	358	390	150	0·44	17·4	21·8
108	"	2,518	2,463	2,118	1,981	127	121	231	352	28·4	4,120	100	252	345	137	0·34	14·0	17·7
60	Yellowhead Pass.	4,220	3,971	3,511	3,404	144	377	63	440	18·9	2,740	83	357	460	107	0·86	10·4	15·0
74	" ..	3,898	3,668	3,228	2,950	145	217	309	526	38·7	5,620	204	322	440	278	0·41	13·5	19·6
55	Pembina..........	5,203	4,320	3,810	3,713	176	374	125	499	16·1	2,340	80	419	510	97	0·75	9·6	16·9
52	Cardiff...........	5,674	4,470	4,040	3,965	197	357	127	484	14·9	2,160	72	412	430	75	0·74	8·5	16·8
53	Twin City........	5,577	4,573	4,127	4,023	191	408	107	515	18·9	2,740	97	418	446	104	0·79	9·2	17·7
58	Drumheller.......	4,823	3,940	3,260	2,956	212	779	205	984	30·9	4,480	304	680	680	304	0·79	20·4	43·2
76	"	4,242	3,444	2,842	2,386	270	391	637	1,028	43·1	6,250	443	585	602	456	0·38	24·2	65·3
61	Newcastle........	4,910	4,100	3,727	3,630	175	398	72	470	20·6	3,000	80	373	373	97	0·85	9·6	16·8
111	Midland..........	4,164	3,485	3,131	3,027	165	406	42	448	22·7	3,290	102	346	354	104	0·91	10·8	17·7
103	"	3,977	3,333	3,019	2,891	175	226	217	443	28·8	4,170	128	315	314	128	0·51	11·1	19·5
102	"	4,256	3,567	3,231	3,080	183	200	213	413	31·0	4,510	128	285	336	151	0·48	9·7	17·8

TABLE IV.

Detailed Report of Trials—*Continued.*

No. of Trial.	Name of Fuel.	Fuel, total quantities. Fuel fired. As fired.	Dry.	*Combustible. Fired.	Con-sumed.	Fuel fired per 1,000 lbs. water evaporated from and at 212° F.	Ash and Refuse. Refuse removed from Above fire bars.	Ash-pit.	Ash-pit and above fire bars.	*Combustible in refuse removed.	Calorific value of refuse per lb.	Total weight *combustible in refuse removed.	Weight of ash in Refuse.	Fuel fired.	Estimated weight of unconsumed *combustible	Ratio refuse removed from grate to total refuse removed.	Total refuse removed. Per cent of fuel fired.	Per 1,000 lb. steam. from and at 212° F.
1	2	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
		lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	per cent.	B. Th.U.	lb.	lb.	lb.	lb.			lb.
51	Rosedale.........	5,639	4,780	4,350	4,276	184	366	76	442	14·8	2,150	65	377	430	74	0·83	7·8	14·4
114	Bankhead........	3,488	3,453	2,773	2,432	142	878	48	926	33·4	4,860	309	617	680	341	0·95	26·5	37·8
109	"	3,153	3,118	2,538	2,293	136	256	295	551	29·7	4,470	164	387	580	245	0·47	17·5	23·8
110	"	2,700	2,670	2,173	1,907	144	296	248	544	34·9	5,190	190	354	497	266	0·54	20·1	29·1
54	Georgetown.......	3,544	3,440	3,010	2,845	124	420	111	531	27·7	4,020	147	384	430	165	0·79	15·0	18·6
77	"	2,867	2,807	2,429	2,029	136	241	431	672	55·1	7,990	370	302	378	400	0·36	23·4	31·8
69	McGillivray......	3,359	3,275	2,704	2,509	156	628	110	738	25·5	3,700	188	550	571	195	0·85	22·0	34·3
78	"	2,905	2,847	2,350	2,043	142	321	377	698	38·2	5,540	267	431	497	307	0·46	24·0	34·0
112	Hillcrest Seam No. 1.	3,140	3,077	2,643	2,545	125	386	47	433	18·5	2,680	80	353	434	98	0·89	13·8	17·2
105	" " ..	2,786	2,733	2,343	2,242	125	68	312	380	20·4	2,970	78	302	390	101	0·18	13·6	17·0
106	" " ..	2,595	2,545	2,182	2,072	130	91	262	353	23·2	3,360	82	271	363	110	0·26	13·6	17·7
67	Bellevue..........	3,714	3,614	2,916	2,725	165	693	93	786	21·5	3,120	169	617	698	191	0·88	21·2	35·0
80	"	3,163	3,097	2,547	2,334	152	317	384	701	27·9	4,050	195	506	550	213	0·45	22·1	33·7
68	Greenhill.........	3,281	3,199	2,822	2,690	136	436	77	513	25·9	3,760	133	380	377	132	0·85	15·6	21·3
81	"	2,964	2,916	2,522	2,356	132	329	196	525	29·6	4,290	155	370	394	166	0·63	17·7	23·5

70	Frank............	3,462	3,365	2,749	2,511	162	705	117	822	27·8	4,030	229	593	616	238	0·86	23·7	38·5
79	"	3,152	3,098	2,553	2,246	154	342	510	852	36·1	5,240	307	545	545	307	0·40	27·0	41·7
100	Chinook..........	4,009	3,616	3,083	2,924	174	374	297	671	23·0	3,380	154	517	533	159	0·56	16·7	29·2
101	"	3,939	3,553	3,029	2,884	182	318	208	526	21·7	3,110	114	412	524	145	0·61	13·4	24·4
71	Machine peat from Alfred, Ont.	4,663	3,931	3,740	3,664	244	207	34	241	28·5	4,130	69	172	191	76	0·86	5·2	12·6
72	" " ..	5,844	4,927	4,687	4,536	252	None.	278	278	38·7	5,610	108	170	240	151	0·0	4·8	12·1
73	" " ..	5,690	4,535	4,290	4,197	253	146	78	224	27·6	4,000	62	162	245	93	0·65	3·9	10·0
83	" " ..	1,271	1,027	975	973	257	None.	27	27	4·3	620	1	26	52	2	0·0	2·1	5·5
84	" " ..	1,715	1,370	1,289	1,283	267	"	33	33	6·6	960	2	31	81	6	0·0	1·9	5·1
85	" " ..	2,720	2,198	2,084	2,075	324	"	76·5	76·5	7·5	1,090	6	71	114	9	0·0	2·8	9·1

* "Combustible" means "Ash and Moisture Free Fuel".

TABLE IV.

Detailed Report of Trials—*Continued.*

No. of Trial.	Name of Fuel.	Feed Water and Steam.							Air and Draft.							
		Temperature of feed water in feed tank.	Total weight of water.			Boiler steam pressure.		Moisture content of steam.	Temperature of air in boiler room.	Barometric pressure.	Draft.			Air used per lb. of fuel fired.	Air theoretically required per lb. of fuel fired.	Ratio of air used to air theoretically required.
			Fed to the boiler.	Evaporated.		By gauge.	Absolute.				In ash-pit.	Over fire.	In flue leaving the boiler.			
				Corrected for moisture.	From and at 212° F.											
1	2	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
		°F.	lb.	lb.	lb.	Lb. per sq. in.	Lb. per sq. in.	per cent.	°F.	Inches of mercury	Inches of water.	Inches of water.	Inches of water.	lb.	lb.	....
59	Jasper Park........................	81	22,898	22,670	26,600	93	108	1·2	64	30·19	0·0	0·33	0·64	21·0	8·8	2·4
75	"	110	19,000	18,860	21,570	94	109	0·9	79	29·59	0·0	0·15	0·59	19·3	9·2	2·1
113	Mountain Park......................	107	21,540	21,370	24,670	111	126	1·02	75	29·90	0·0	0·30	0·42	14·8	9·6	1·5
107	"	93	19,570	19,500	22,730	112	127	0·48	80	29·95	0·0	0·08	0·20	13·4	9·6	1·4
108	"	74	16,900	16,740	19,900	110	125	1·22	80	29·76	0·0	0·24	0·76	16·3	9·6	1·7
60	Yellowhead Pass....................	78	25,168	24,960	29,380	96	111	1·0	71	29·96	0·0	0·18	0·47	14·9	8·2	1·8
74	"	104	23,500	23,340	26,900	107	122	0·9	90	29·86	0·0	0·05	0·17	11·8	8·2	1·4
55	Pembina............................	37	24,325	24,150	29,480	109	124	1·0	74	30·08	0·0	0·21	0·63	15·7	7·0	2·3
52	Cardiff............................	35·5	23,740	23,590	28,840	108	123	0·8	87	30·11	0·0	0·20	0·46	11·2	6·6	1·7
53	Twin City..........................	35	23,965	23,820	29,130	107	122	0·8	85	29·85	0·0	0·21	0·63	13·7	6·9	2·0
58	Drumheller.........................	39	18,883	18,720	22,770	94	109	1·2	71	29·99	0·0	0·33	0·64	15·1	6·4	2·4
76	"	118	13,950	13,840	15,740	105	120	1·01	80	29·79	0·0	0·29	0·73	15·7	6·3	2·5
61	Newcastle..........................	74	23,898	23,700	28,000	91	106	0·9	73	29·86	0·0	0·14	0·41	12·9	7·2	1·8

111	Midland	91	21,740	21,590	25,280	111	126	0·9	80	29·82	0·0	0·21	....	10·7	7·2	1·5
103	"	96	19,670	19,500	22,700	110	125	1·1	90	30·38	0·0	0·04	0·12	8·6	7·3	1·2
102	"	70	19,100	18,910	23,280	100	115	1·26	79	30·19	0·0	0·20	0·79	10·5	7·3	1·4
51	Rosedale	38	25,287	25,130	30,645	108	123	0·9	79	29·57	0·0	0·21	0·57	15·3	7·3	2·1
114	Bankhead	107	21,440	21,270	24,530	105	120	1·0	70	29·69	0·0	0·53	0·79	17·6	9·2	1·9
109	"	89	19,910	19,750	23,170	108	122	1·0	80	29·60	0·0	0·45	0·64	16·9	9·3	1·8
110	"	68	15,830	15,650	18,700	108	123	1·48	80	29·80	0·0	0·84	1·32	16·0	9·3	1·7
54	Georgetown	37	23,520	23,370	28,530	105	120	0·8	82	30·12	0·0	0·32	0·68	23·1	10·0	2·3
77	"	104	18,400	18,300	21,070	107	122	0·8	88	29·88	0·0	0·29	0·59	19·5	10·0	1·9
69	McGillivray	113	19,015	18,920	21,480	113	128	1·1	78	29·81	0·0	0·37	0·74	22·9	9·1	2·5
78	"	122	18,250	18,130	20,520	97	112	0·8	90	29·68	0·0	0·25	0·54	18·2	9·2	2·0
112	Hillcrest, seam No. 1	93	21,650	21,460	25,100	111	126	1·1	78	29·30	0·0	0·39	0·54	14·9	9·5	1·6
105	" "	94	19,270	19,150	22,360	110	124	0·92	78	29·10	0·0	0·13	0·28	16·0	9·5	1·7
106	" "	71	16,900	16,770	19,970	108	122	0·99	90	29·93	0·0	0·29	0·85	17·9	9·5	1·9
67	Bellevue	107	19,750	19,580	22,460	92	107	1·1	66	30·26	0·0	0·28	0·71	24·3	9·1	2·7
80	"	108	18,250	18,370	20,820	105	120	0·8	93	29·70	0·0	0·28	0·69	20·6	9·2	2·2
68	Greenhill	110	21,185	21,040	24,070	96	111	0·8	74	30·08	0·0	0·31	0·67	23·2	10·0	2·3
81	"	129	20,000	20,130	22,390	113	128	0·8	87	29·56	0·0	0·18	0·57	20·4	9·9	2·1
70	Frank	119	18,950	18,810	21,340	94	109	0·9	76	30·12	0·0	0·37	0·76	21·9	8·9	2·5
79	"	133	18,350	18,230	20,450	106	121	0·8	78	29·89	0·0	0·37	0·87	21·8	9·2	2·4
100	Chinook	97	19,910	19,750	23,000	105	120	1·02	78	30·0	0·0	0·04	0·20	10·1	7·7	1·3
101	"	76	18,378	18,190	21,600	107	122	1·3	70	29·98	0·0	0·16	0·69	10·1	7·7	1·3
71	Machine peat from Alfred, Ont.	124	17,045	16,930	19,120	99	114	0·9	71	29·7	0·0	0·23	0·71	11·9	5·7	2·1
72	" "	118	20,500	20,370	23,150	101	116	0·8	72	29·8	0·0	0·11	0·35	9·3	5·7	1·6
73	" "	115	19,900	19,750	22,490	94	109	0·9	89	29·9	0·0	0·18	0·57	10·7	5·4	2·0
83	" "	59	4,242	4,135	4,946	95	110	2·9	70	29·9	....	....	0·11	9·5	5·5	1·7
84	" "	60	5,504	5,374	6,418	94	109	3·2	70	29·6	....	....	0·14	8·9	5·4	1·6
85	" "	54	7,209	7,007	8,398	80	95	3·6	68	29·8	....	....	0·22	6·2	5·5	1·1

TABLE IV.

Detailed Report of Trials—*Continued.*

No. of Trial.	Name of Fuel.	Flue Gases. Analysis of dry flue gases by volume. Carbon dioxide.	Carbon monoxide.	Oxygen.	Nitrogen.	Dry flue gases per lb. Carbon in gas.	Fuel as fired.	Temperature in flue leaving boiler.	Hourly Quantities and Rates. Fuel fired.	Fuel fired per sq. ft. of grate surface.	Dry fuel fired per sq. ft. of grate surface.	Equivalent evaporation from and at 212° F.	Equivalent evaporation from and at 212° F. per sq. ft. of heating surface.	Boiler horse-power.	Water Fuel Ratios. Equivalent water evaporated per lb. of fuel as fired.	Equi. Evap. from and at 212° F. Per lb. of fuel as fired.	Per lb. of dry fuel fired.	Per lb. *combustible consumed.
1	2	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
		per cent.	per cent.	per cent.	per cent.	lb.	lb.	° F.	lb.	lb.	lb.	lb.	lb.		lb.	lb.	lb.	lb.
59	Jasper Park.......	7·0	0·1	12·6	80·3	34·8	21·3	660	324	14·0	13·6	2,220	3·27	64·2	5·84	6·85	7·01	9·74
75	"	7·7	0·1	11·9	80·3	31·7	19·6	690	323	15·5	15·3	2,130	3·15	61·8	5·78	6·61	6·71	9·24
113	Mountain Park....	10·9	0·6	7·7	80·8	21·8	15·0	590	281	12·2	11·9	2,240	3·31	64·9	6·93	7·99	8·22	9·93
107	"	11·7	0·7	6·9	80·7	20·3	13·7	590	284	13·5	13·2	2,270	3·35	65·8	6·86	7·99	8·18	10·14
108	"	9·9	0·2	9·5	80·4	24·7	16·7	720	420	20·0	19·6	3,330	4·92	96·5	6·65	7·91	8·08	10·04
60	Yellowhead Pass.	9·6	0·6	9·6	80·2	24·4	15·2	730	352	15·2	14·3	2,450	3·62	71·0	5·92	6·96	7·40	8·63
74	" ..	11·3	0·6	7·8	80·3	21·1	12·2	680	320	15·4	14·5	2,210	3·3	64·1	5·98	6·90	7·33	9·12
55	Pembina.........	7·7	0·4	12·1	79·8	30·6	16·1	645	434	18·7	15·5	2,456	3·63	71·2	4·64	5·67	6·83	7·94
52	Cardiff...........	10·2	0·7	9·1	80·0	22·9	11·5	670	473	20·4	16·1	2,404	3·55	69·7	4·16	5·08	6·45	7·28
53	Twin City........	9·0	0·2	10·8	80·0	27·1	14·0	690	465	20·0	16·8	2,427	3·59	70·4	4·27	5·23	6·37	7·24
58	Drumheller.......	6·9	0·2	12·9	80·0	34·7	15·3	580	405	17·4	14·3	1,911	2·82	55·4	3·88	4·72	5·78	7·71
76	"	6·0	0·1	14·0	79·9	40·3	15·9	600	412	19·8	16·1	1,530	2·26	44·4	3·26	3·71	4·57	6·60
61	Newcastle........	9·8	0·5	9·4	80·3	24·2	13·2	730	409	17·6	14·7	2,333	3·45	67·6	4·83	5·70	6·83	7·72
111	Midland..........	11·4	0·7	8·3	79·4	20·6	11·2	580	379	16·5	13·8	2,300	3·4	66·7	5·18	6·07	7·25	8·35
103	"	13·6	1·7	4·4	80·3	16·5	8·9	560	398	18·9	15·9	2,270	3·35	65·8	4·91	5·71	6·81	7·85
102	"	11·1	1·4	7·3	80·2	20·0	10·7	840	715	34·0	28·5	3,910	5·78	113·4	4·44	5·47	6·52	7·56

51	Rosedale.........	8·5	0·3	11·3	79·9	28·2	15·7	730	470	20·2	17·1	2,554	3·77	74·0	4·46	5·43	6·41	7·17
114	Bankhead........	8·5	0·1	11·2	80·2	28·9	17·9	540	318	13·8	13·7	2,230	3·29	64·6	6·10	7·04	7·11	10·09
109	"	9·2	0·2	10·3	80·3	26·5	17·2	550	312	14·9	14·7	2,290	3·38	66·4	6·26	7·35	7·43	10·10
110	"	9·3	0·3	10·0	80·4	25·9	16·3	680	448	21·3	21·1	3,100	4·58	90·0	5·80	6·93	7·00	9·80
54	Georgetown.......	7·5	0·05	12·35	80·01	32·8	23·5	630	295	12·7	12·3	2,377	3·51	68·9	6·59	8·05	8·29	10·03
77	"	7·8	0·05	11·09	80·25	31·6	19·8	620	289	13·9	13·6	2,130	3·15	61·7	6·38	7·35	7·51	10·39
69	McGillivray......	6·7	0·1	13·1	80·1	36·3	23·2	710	282	12·2	11·9	1,805	2·67	52·3	5·63	6·39	6·56	8·56
78	"	7·9	0·1	11·7	80·3	31·0	18·4	610	295	14·2	13·9	2,080	3·08	60·4	6·24	7·06	7·21	10·04
112	Hillcrest, seam No. 1	10·8	0·4	8·3	80·3	22·1	15·3	610	285	12·4	12·2	2,280	3·37	66·1	6·84	7·99	8·16	9·86
105	" " ..	10·2	0·3	8·7	80·8	23·8	16·3	610	276	13·1	12·9	2,220	3·28	64·3	6·88	8·02	8·18	9·97
106	" " ..	9·2	0·1	10·1	80·6	26·8	18·2	740	430	20·5	20·1	3,320	4·90	96·2	6·46	7·70	7·85	9·64
67	Bellevue...... . .	6·2	0·1	13·7	80·0	39·1	24·6	705	310	13·4	13·0	1,880	2·77	54·4	5·27	6·05	6·21	8·24
80	"	7·4	0·1	12·2	80·3	33·0	20·9	670	313	15·0	14·7	2,060	3·04	59·7	5·81	6·58	6·72	8·92
68	Greenhill.........	7·4	0·1	12·3	80·2	33·0	23·6	720	273	11·8	11·5	2,006	2·96	58·1	6·41	7·33	7·52	8·95
81	"	8·2	0·1	11·3	80·4	29·9	20·7	710	297	14·3	14·1	2,250	3·32	65·1	6·79	7·56	7·68	9·50
70	Frank............	6·7	0·1	13·0	80·2	36·3	22·1	720	292	12·6	12·2	1,802	2·66	52·2	5·43	6·16	6·34	8·49
79	"	6·6	0·1	13·2	80·1	36·8	22·2	670	317	15·2	15·0	2,055	3·04	59·6	5·78	6·49	6·60	9·11
100	Chinook..........	11·8	1·5	6·2	80·5	18·9	10·4	580	402	19·1	17·3	2,310	3·4	67·0	4·93	5·74	6·36	7·87
101	"	11·5	1·6	6·7	80·2	19·1	10·5	840	660	31·4	28·4	3,620	5·4	104·8	4·62	5·49	6·08	7·49
71	Machine peat from Alfred, Ont.	8·6	0·6	11·1	79·7	27·0	12·2	720	476	20·5	17·3	1,950	2·88	56·5	3·63	4·10	4·87	5·22
72	" " ..	10·5	1·1	8·8	79·6	21·6	9·6	760	586	15·5	13·1	2,322	3·43	67·3	3·49	3·96	4·70	5·10
73	" " ..	8·9	0·8	10·7	79·6	25·6	10·9	715	569	15·0	12·0	2,250	3·32	65·2	3·47	3 95	4 96	5·36
83	" " ..	10·0	1·4	9·0	79·6	21·9	9·8	690	160	17·7	14·3	621	2·89	18·0	3·25	3·89	4·81	5·08
84	" " ..	10·5	1·5	8·2	79·8	20·8	9·1	690	214	23·8	19·0	802	3·73	23·2	3·13	3·74	4·69	5·00
85	" " ..	12·6	4·7	4·0	78·7	14·5	6·5	750	341	37·9	30·7	1,054	4·9	30·5	2·57	3·09	3·82	4·05

* "Combustible" means "Ash and Moisture Free Fuel".

TABLE IV.

Detailed Report of Trials—*Concluded.*

No. of Trial.	Name of Fuel.	Efficiencies. Efficiency of Boiler, furnace and grate based on calorific value. Gross.	Net.	Grate based on net calorific value.	Boiler based on *combustible consumed and net calorific value.	Heat Balance based on Fuel as Fired, and gross Calorific Value. Total heat value of one lb. of fuel as fired gross value.	Heat transferred to the water.		Loss due to total heat of steam formed from moisture in fuel and that formed by combustion of hydrogen.		Loss due to heat carried away in the dry flue gases, due to its high temperature.		Loss due to unburnt *combustible in the refuse.		Loss due to unburnt carbon monoxide.		Balance of heat account; errors of observation and unmeasured losses such as those due to radiation, heat in hot ashes, etc.	
1	2	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98
		per cent.	per cent.	per cent.	per cent.	B. Th.U.	B. Th.U.	per cent.	B. Th.U.	per cent.	B. Th.U.	per cent.	B. Th.U.	per cent.	B. Th.U.	per cent.	B. Th.U.	per cent.
59	Jasper Park.......	57·4	59·4	93·6	64·5	11,580	6,650	57·4	480	4·2	3,030	26·2	860	7·4	90	0·7	470	4·1
75	"	52·8	54·6	90·1	61·0	12,150	6,410	52·8	490	4·0	2,870	23·6	1,240	10·2	80	0·7	1,060	8·7
113	Mountain Park....	61·2	63·5	97·0	65·8	12,670	7,760	61·2	550	4·3	1,850	14·6	430	3·4	370	2·9	1,710	13·6
107	"	60·7	62·8	94·3	67 0	12,780	7,760	60 7	530	4 1	1,680	13 1	770	6 0	390	3·1	1,650	13·0
108	"	60·0	62·2	95·3	66·4	12,780	7,670	60·0	560	4·4	2,570	20·1	790	6·2	140	1·1	1,050	8·2
60	Yellowhead Pass.	61·8	64·4	97·3	66·9	10,930	6,760	61·8	560	5·1	2,370	21·7	370	3·4	370	3·4	500	4·6
74	" ..	61·5	64·2	92·7	71·2	10,880	6,690	61·5	510	4·7	1,730	15·9	1,030	9·5	290	2·7	630	5·7
55	Pembina..........	61·2	65·1	97·3	67·4	8,980	5,500	61·2	680	7·6	2,210	24·6	270	3·0	260	2·9	60	0·7
52	Cardiff...........	57·5	61·7	97·7	63·2	8,570	4,930	57·5	720	8·4	1,610	18·8	190	2·2	330	3·9	790	9·2
53	Twin City........	55·8	59·5	97·0	61·4	9,090	5,070	55·8	710	7·8	2,030	22·3	270	3·0	110	1·2	900	9·9
58	Drumheller.......	54·0	57·5	88·5	64·9	8,490	4,590	54·0	630	7·4	1,870	22·0	910	10·8	130	1·5	360	4·3
76	"	42·8	45·6	80·9	56·8	8,420	3,600	42·8	640	7·6	1,990	23·6	1,560	18·5	70	0·8	560	6·7
61	Newcastle........	57·7	61·1	96·8	63·1	9,590	5,530	57·7	670	7·0	2,080	21·7	290	3·0	270	2·8	750	7·8

111	Midland..........	61·4	64·9	96·1	67·6	9,590	5,890	61·4	640	6·7	1,340	14·0	360	3·8	320	3·3	1,040	10·8
103	"	57·2	60·5	94·9	63·8	9,680	5,540	57·2	630	6·5	1,000	10·3	470	4·9	610	6·3	1,430	14·8
102	"	54 9	58·0	95·2	61·5	9,680	5,310	54·9	700	7·2	1,950	20·2	520	5·3	610	6·3	590	6·1
51	Rosedale.........	54·9	58·1	98·1	59·4	9,600	5,270	54·9	680	7·1	2,450	25·5	190	2·0	190	2·0	820	8·5
114	Bankhead........	56·8	58·3	89·0	66·3	12,030	6,830	56·8	380	3·1	2,020	16·8	1,420	11·8	70	0·6	1,310	10·9
109	"	58·5	60·1	93·4	66·6	12,180	7,130	58·5	380	3·1	1,940	15·9	1,170	9·6	140	1·2	1,420	11·7
110	"	55·2	56·6	91·2	64·4	12,180	6,720	55·2	400	3·3	2,350	19·3	1,430	11·7	200	1·6	1,080	8·9
54	Georgetown.......	60·4	62·4	95·2	65·9	12,920	7,810	60·4	490	3·8	3,090	23·9	680	5·3	50	0·4	800	6·2
77	"	55·3	57·0	84·1	67·9	12,900	7,130	55·3	480	3·7	2,520	19·5	2,020	15·7	40	0·3	710	5·5
69	McGillivray......	51·6	53·4	93·0	57·6	12,040	6,210	51·6	530	4·4	3,500	29·0	840	7·0	100	0·8	860	7·2
78	"	56·6	58·6	88·6	67·6	12,100	6,860	56·6	510	4·2	2,300	19·0	1,530	12·7	80	0·7	820	6·8
112	Hillcrest, seam	60·5	62·5	97·0	64·9	12,830	7,760	60·5	560	4·4	1,950	15·2	460	3·5	250	2·0	1,850	14·4
105	" No. 1.	60 6	62·7	96·7	65·4	12,840	7·780	60·6	560	4·4	2,070	16·1	520	4·1	200	1·5	1,710	13·3
106	"	58·2	60·2	96·3	63·4	12,840	7,480	58·2	580	4·6	2,840	22·1	610	4·8	70	0·5	1,260	9·8
67	Bellevue..........	49·8	51·7	94·2	55·2	11,790	5,870	49·8	510	4·3	3,770	32·0	750	6·3	100	0·9	790	6·7
80	"	52·8	54·8	92·3	59·6	12,080	6,390	52·8	490	4·1	2,920	24·2	980	8·1	90	0·7	1,210	10·1
68	Greenhill.........	54·2	56·1	95·4	58·8	13,140	7,120	54·2	530	4·0	3,680	28·0	580	4·4	100	0·8	1,130	8·6
81	"	56·4	58·3	94·0	62·4	13,000	7,330	56·4	500	3·9	3,110	23·9	810	6·3	80	0·6	1,170	8·9
70	Frank............	50·2	52·1	91·7	57·0	11,910	5,980	50·2	490	4 1	3,400	28·5	1,000	8·4	90	0·8	950	8 0
79	"	51·8	53·7	87·9	61·1	12,150	6,300	51·8	460	3·8	3,140	25·8	1,410	11·6	90	0·8	750	6·2
100	Chinook..........	54·5	57·4	94·2	61·1	10,210	5,570	54·5	610	6·0	1,250	12·2	590	5·8	630	6·2	1,560	15·3
101	"	52·2	54·9	95·7	58·1	10,210	5,330	52·2	680	6·6	1,940	19·0	530	5·2	690	6·8	1,040	10·2
71	Machine peat from Alfred, Ont.	49·3	53·1	97·1	54·9	8,070	3,980	49·3	720	8·9	1,900	23·6	240	3·0	300	3·8	930	11·4
72	"	47·6	51·3	96·4	53·9	8,070	3,840	47·6	730	9·0	1,590	19·7	370	4·6	430	5·3	1,110	13·8
73	"	50·5	54·8	97·8	56·8	7,590	3,830	50·5	730	9·7	1,640	21·6	240	3·2	360	4·8	790	10·2
83	"	48·8	52·9	99·8	53·0	7,730	3,770	48·8	760	9·8	1,460	18·9	20	0·3	560	7·2	1,160	15·0
84	"	48·0	52·1	99·7	52·5	7,570	3,630	48·0	750	9·9	1,350	17·9	50	0·7	560	7·4	1,230	16·1
85	"	38·9	42·2	99·6	42·5	7,710	3,000	38·9	770	10·0	1,060	13·7	50	0·6	1,230	16·0	1,600	20·8

*"Combustible" means "Ash and Moisture Free Fuel".

GENERAL REMARKS.

Trial No. 59: Jasper Park.—This fuel cakes considerably and it was necessary to break up the fuel bed frequently during the trial. The fire was cleaned twice during the trial, the clinker was in small pieces, and it was difficult to separate it from the coal when cleaning.

Trial No. 75: Jasper Park.—The fire was cleaned twice during the trial; it was sliced frequently to counteract the caking tendency of the fuel. The clinker was easily removed, it neither spread nor adhered to the bars.

Trials Nos. 59 and 75.—A comparison of the results of these trials shows that the grate bars with the smaller air space as used in trial 59 to be better adapted for this fuel.

Trial No. 113: Mountain Park.—The fire was cleaned twice during the trial, and raked frequently to break up the fuel bed and counteract the caking tendencies of the fuel. The clinker was in small pieces and would pass through a shaking grate. Considerable quantities of smoke were given off.

Trial No. 107: Mountain Park.—The fire was cleaned twice during the trial, and sliced three times; the clinker was in small pieces which were easily removed. The coal caked and it was necessary to break it up with a rake from time to time. Considerable heavy black smoke was given off.

Trial No. 108: Mountain Park.—The fire was cleaned once during the trial; it was raked frequently to counteract the caking tendency of the coal. Considerable quantities of smoke were given off.

Trials Nos. 107, 108, and 113.—There is very little difference in the economical results of these three trials. The evaporation per pound of fuel was as high as 7·91 when the boiler steamed $1\frac{1}{2}$ times as rapidly as during the remaining two trials when the evaporation was 7·99. This small difference in evaporation was unusual, since at the higher rate of steaming the flue gas loss is considerably increased, and it is to be accounted for by the more complete combustion of the fuel at the higher rate of steaming.

Trial No. 60: Yellowhead Pass.—The fire was cleaned twice during the trial; the clinker spread over the bars, and was removed in fairly large pieces. Considerable quantities of black smoke were given off after firing, which soon cleared off.

Trial No. 74: Yellowhead Pass.—The fire was cleaned twice during the trial and sliced three times; the clinker spread over the bars, but there was no difficulty about its removal.

Trials Nos. 60 and 74.—A comparison of the results of both trials shows that they were both carried out at the same rate of fuel consumption per square foot of grate. There was very little difference in the net result; with the larger air space in the bars (Trial 74) the grate efficiency was lower. This loss was almost entirely counteracted by the smaller excess of air (column 62). Both efficiencies are high (column 83), compared with similar trials on this boiler.

Trial No. 55: Pembina.—See report No. 331.

Trial No. 52: Cardiff.—See report No. 331.

Trial No. 53: Twin City.—See report No. 331.

Trial No. 58: Drumheller.—Steam-raising with this fuel was rendered difficult by the rapid formation of clinker which spread over the bars and

obstructed the air supply. The clinker had to be removed on nine separate occasions during the trial, and the fire was frequently sliced to raise the clinker off the bars. Very little smoke was observed.

Trial No. 76: Drumheller.—The fire was cleaned six times during the trial, this was necessary on account of clinker spreading over the bars. On refiring after cleaning considerable quantities of fuel passed through the wide air spaces, which accounts for the low grate efficiency.

Trials Nos. 58 and 76.—A comparison of the results of both trials shows the smaller air space between the bars (trial 58) to have been better adapted for this fuel, which consists principally of very small particles which passed in large quantities through the wider bars when refiring after cleaning. During both trials much labour was necessary for the removal of clinker from the grate bars. The fuel burned with very little smoke.

Trial No. 61: Newcastle.—The fire was cleaned twice during the trial; there was very little trouble with the clinker, most of which would have passed through a shaking grate. A fairly dense black smoke was given off.

Trial No. 111: Midland.—The fire was cleaned twice and raked or sliced occasionally. The clinker, which was in large, thin slabs, was easily pried off the bars with a slice bar. Very little smoke was given off. The flue gas during this trial was analysed for methane and hydrogen and gave the following results. Methane 0·1 per cent and hydrogen 0·1 per cent. This represents a loss due to unburnt hydrogen and hydro-carbons of 190 B.Th.U. per pound of fuel fired or 2·0 per cent of its gross calorific value.

Trial No. 103: Midland.—Occasional slicing was necessary, owing to a thin clinker which spread over the bars. There was little trouble in removing this clinker, which was easily broken up. The fire was cleaned twice during the trial. A small amount of light smoke was given off.

Trial No. 102: Midland.—This fuel formed a clinker which spread over the bars, requiring occasional slicing; it was broken up easily and removed without difficulty. The fire was cleaned twice during the trial. A small amount of light smoke was given off.

Trials Nos. 102, 103, and 111.—The use of a larger grate and smaller air spaces in trial 111 led to more economical results than those obtaining in trial 103, due to more perfect combustion of the solid and gaseous components and products. This was partially due to the admission of air over the bars. Unless special precautions are taken, a fairly large quantity of unburnt gases will pass off with the flue gases when burning this fuel.

Trial No. 51: Rosedale.—See report No. 331.

Trial No. 114: Bankhead.—The fire was cleaned three times during this trial, and sliced once. The small air spaces between the bars were not suited to this coal since practically all the refuse had to be removed from above the bars, which meant a poor grate efficiency (column 84) due to the large amount of unburnt fuel removed with the refuse (columns 41 and 43). See also remarks for trial 109.

Trial No. 109: Bankhead.—This coal is rather difficult to handle on an ordinary fixed grate owing to the formation of large pieces of clinker which do not pass through the bars. It is probable that much of the clinker would be removed before it collects into large pieces were a shaking grate used. After removing the refuse when cleaning the fire it was difficult to ignite the fresh fuel, also some of the fuel passed through the bars before the formation of a new bed of fuel. The fire was cleaned twice during the trial and sliced four times. The clinker stuck to the bars at first, but stuck

less after blowing some steam beneath the bars. Practically no smoke was observed.

Trial No. 110: Bankhead.—Clinker formed in the fire in large pieces, and adhered to the bars a little, this adhesiveness was reduced by passing steam beneath the bars with the air supply. The fire was cleaned twice and sliced twice during the trial. Very little smoke was given off.

Trials Nos. 109, 110, and 114.—From Table IV it will be observed that trial 110 was carried out at a much higher rate of steaming (see column 75) than the remaining two trials which were carried out at practically the same rate. A comparison of the two latter trials (109 and 114) shows the results of 109 to be the better, which is to be attributed to the use of a grate with wider air openings than those used for trial 114, which reduced the quantity of refuse to be removed from above the bars, this refuse was so intermingled with the fuel that it was impossible to remove it without removing fuel with it.

Trial No. 54: Georgetown.—See report No. 331.

Trial No. 77: Georgetown.—The fire was cleaned twice, and sliced three times during the trial. The clinker was in medium size pieces and did not spread, though it was found occasionally to be sticking very slightly. Practically no smoke was given off.

Trials Nos. 77 and 54.—For the purpose of comparison a summary of the results of trial 54, (see Report No. 331) has been reproduced above. In this trial fire bars with a smaller air space were used which suited this coal better than the fire bars used in the subsequent trial (77). The loss in efficiency (columns 78 and 83) is seen to be due to the large amount of fuel which escaped unburnt (columns 49 and 84), this loss however was partially counteracted by the reduced excess air supply (columns 62 and 92) due probably to the larger air openings in the fire bars during trial 54.

Trial No. 69: McGillivray.—The fire was cleaned twice during the trial, and sliced about once every hour to break up the fuel, which caked considerably. The clinker consisted principally of small pieces which were easily removed. Considerable quantities of smoke were emitted. (See also trial No. 78.)

Trial No. 78: McGillivray.—The fire was cleaned twice during the trial, when the clinker, which consisted of small pieces, was easily removed. Owing to the caking tendency of the coal it was necessary to frequently break up the fire with the rake or slice bar. A shaking grate is recommended for this coal. Considerable quantities of black smoke were emitted. (See also trial 69.)

Trials Nos. 69 and 78.—Fire bars with $\frac{1}{2}$-inch air space were used for trial 78 and $\frac{1}{4}$-inch air space for trial 69. The larger air spaces enabled the ash to pass to the ash-pit more readily, consequently less draft was required to burn the fuel, and the excess air (column 62) was reduced considerably, thereby decreasing the flue gas loss and improving the overall efficiency in spite of the reduction in grate efficiency due to the wider air spaces.

Trial No. 112: Hillcrest.—The fire was cleaned twice during this trial, and the fuel bed was frequently broken up with the rake or slice bar to counteract its caking tendency. (See also general notes for trial 105). The flue gas during this trial was analysed for methane and hydrogen and gave the following results in percentages: methane 0·1; hydrogen 0·1. This represents a loss due to unburnt hydrogen and hydro-carbons based

on the gross calorific value of the fuel as fired of 2·0 per cent, or 250 B.Th.U. per pound of fuel fired.

Trial No. 105: Hillcrest.—The fire was only cleaned once during the trial; the clinker was in small, hard pieces, which were rather difficult to separate from the coal in cleaning. A shaking grate would improve the operation of a boiler with this fuel. The coal caked together, which necessitated frequent breaking up in order to allow the air to pass through. A considerable quantity of black smoke was emitted.

Trial No. 106: Hillcrest.—The fire was cleaned once during the trial, and broken up with the slice bar or rake frequently. (See also general notes for trial 105).

Trials Nos. 105, 106, and 112.—A comparison of the results of trials Nos. 105 and 112, during which the same rate of evaporation prevailed, shows that the efficiencies were almost identical. The wider air spaces used during trial 112, however, are preferable, since it is easier to remove refuse from the ash-pit than from above the bars.

Trial No. 67: Bellevue.—The fire was cleaned three times during the trial; the refuse removed from above the bars was in small pieces which would have easily passed through a shaking grate. Owing to the small air space in the bars, the high ash content of the fuel, and because the fuel caked, difficulty was experienced in keeping up the rate of evaporation. A shaking grate would have undoubtedly improved the boiler efficiency and reduced the labour involved in tending the fire. It was necessary to frequently break up the fire with the slice bar. A considerable quantity of black smoke was observed.

Trial No. 80: Bellevue.—The fire was cleaned twice during the trial, and broken up four times to counteract the slight caking tendency of the fuel. The operation was much improved over that of trial 67, by using bars with a wider air space, which permitted more of the ash to pass through the bars.

Trials Nos. 67 and 80.—Wider air spaces between the fire bars were used for trial 80, which reduced the grate efficiency, but improved the efficiency as a whole by decreasing the surplus air supply.

Trial No. 68: Greenhill.—The fire was cleaned twice during the trial, the refuse consisting mostly of small, soft dirt, easily removed. A considerable amount of black smoke was emitted.

Trial No. 81: Greenhill.—The fire was cleaned twice during the trial. The refuse removed contained a few hard pieces of clinker. A shaking grate would be suitable for this fuel. A small amount of air was admitted over the bars through the grills in the fire door. A considerable quantity of black smoke was given off.

Trials Nos. 68 and 81.—Burning the coal over larger air spaces between the fire bars (Trial 81) was a more economical method than using a larger grate area and smaller air spaces, owing to a smaller excess of air supply, the gain due to which was partially offset by a poorer grate efficiency.

Trial No. 70: Frank.—This coal cakes a great deal, and had to be broken up frequently during the trial. The fire was cleaned twice during the trial; the refuse was in small soft pieces, most of which would be removed by means of a shaking grate. A fair amount of black smoke was emitted.

Trial No. 79: Frank.—This coal cakes a great deal, and the fuel bed was sliced frequently to enable the air to pass through it. The fire was

cleaned twice during the trial; the refuse removed consisted of soft dirt, which was removed easily. A fair amount of black smoke was given off.

Trials Nos. 70 and 79.—For trial 70 the fuel was burned on a larger grate with smaller air spaces than for trial 79. The results for the latter trial will be seen to be the better, in spite of a lower grate efficiency. By comparison with other fuels burned under similar conditions the overall efficiency (column 83) is rather low.

Trial No. 100: Chinook.—A thin clinker spread over the bars; it did not stick and was easily broken up. The fire was cleaned twice, and sliced six times. Owing to the high carbon monoxide content of the flue gas, air was admitted through the fire doors, in spite of which the loss due to unburnt gases was high. A fairly dense, chocolate-coloured smoke was given off.

Trial No. 101: Chinook.—This fuel was burnt at a much greater rate than in the previous trial. The clinker spread over the bars and was sticking to them a little; on blowing a small amount of steam in with the air the conditions were improved and the clinker no longer adhered to the bars. Air was admitted through the fire door to burn some of the carbon monoxide. Considerable smoke was emitted.

Trials Nos. 100 and 101.—This fuel was used for two trials, one at the normal rate of steaming, and the other (101) when the boiler was forced. The efficiencies were fairly good; the loss due to unburnt gases was very high. A specially large furnace and properly arranged supplementary air supply would probably mean an increase in efficiency of three or four per cent by providing means for the combustion of these gases.

Trial No. 71: Machine Peat.—Air was admitted over the bars during most of the trial. Dense rather light-coloured smoke was emitted. There was no clinker. The fire was cleaned twice during the trial.

Trial No. 72: Machine Peat.—Air was admitted over the bars. Dense light-coloured smoke was given off.

Trial No. 73: Machine Peat.—Air was admitted over bars. Considerable smoke. Fire cleaned twice during the trial.

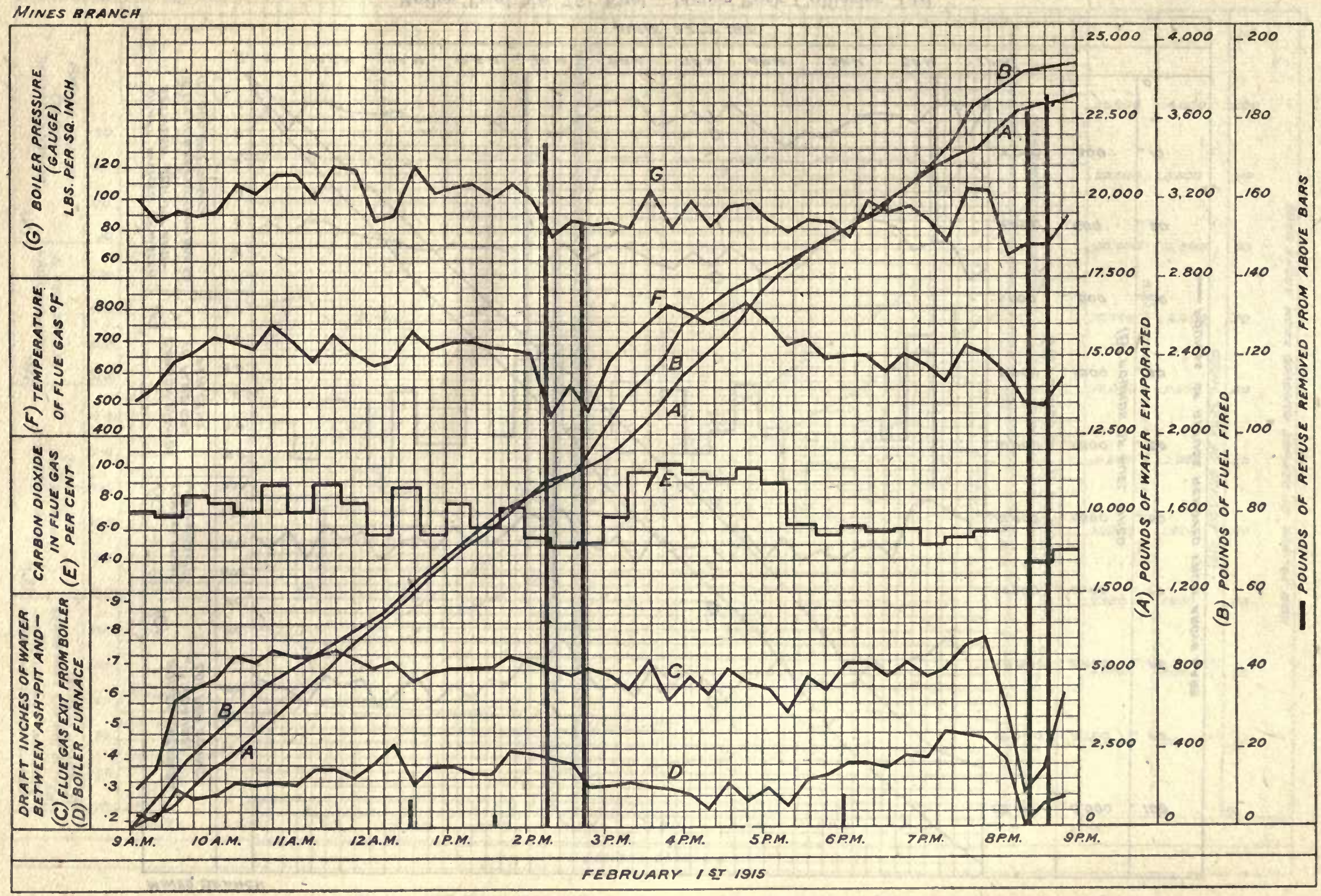
Trial No. 83: Machine Peat.—The fire door was kept open during the first part of the trial and the grills were open in the fire door during the whole trial. The flame from the burning peat filled the combustion chamber. A considerable quantity of smoke was given off.

Trial No. 84: Machine Peat.—The peat burnt with considerable flame which filled the combustion chamber, the fire door was kept partially open during most of the trial in order to augment the air supply. A thin fire was maintained. A good deal of smoke was given off.

Trial No. 85: Machine Peat.—The small grill in the fire door was kept open to admit air above the bars. Considerable quantity of smoke was emitted.

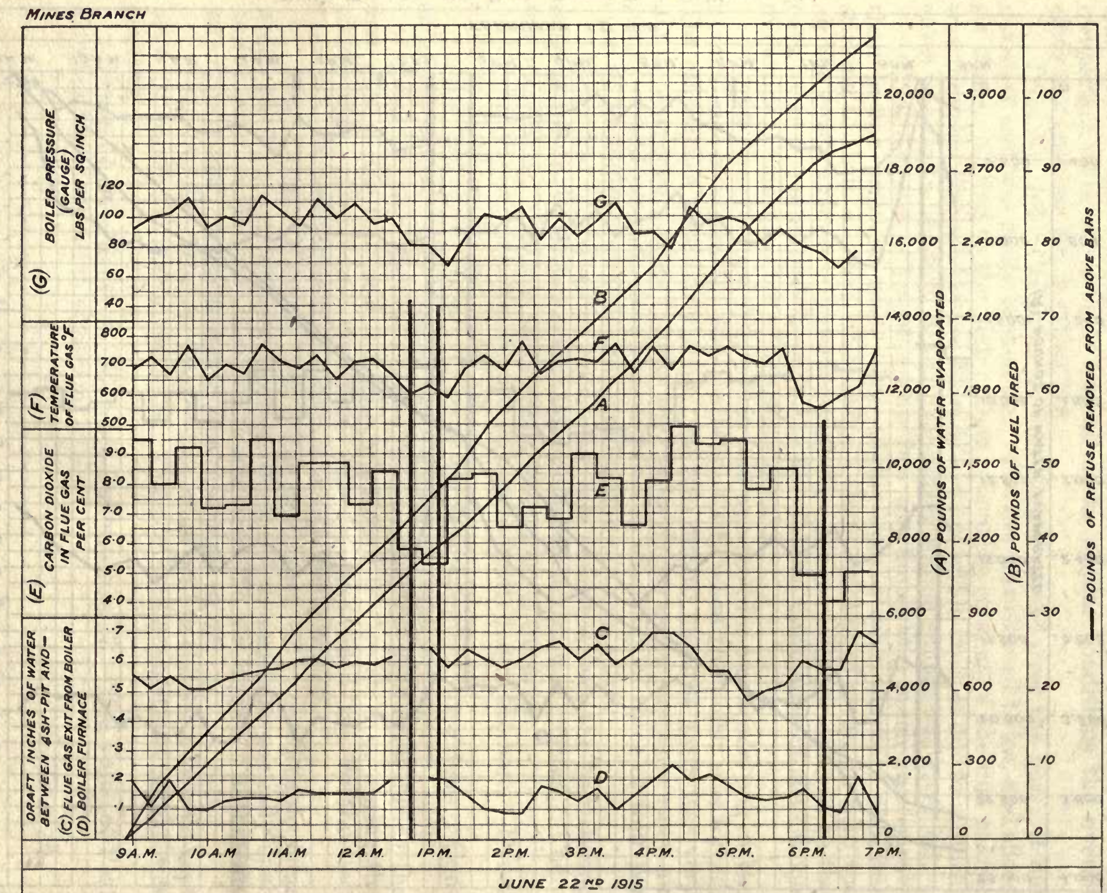
Trials 71, 72, 73, 83, 84, 85.—See Bulletin No. 17. The Value of Peat Fuel for the Generation of Steam.

Chart No. 1.



Boiler Trial No. 59: Fuel—Jasper Park Collieries, Ltd.

Chart No. 2.

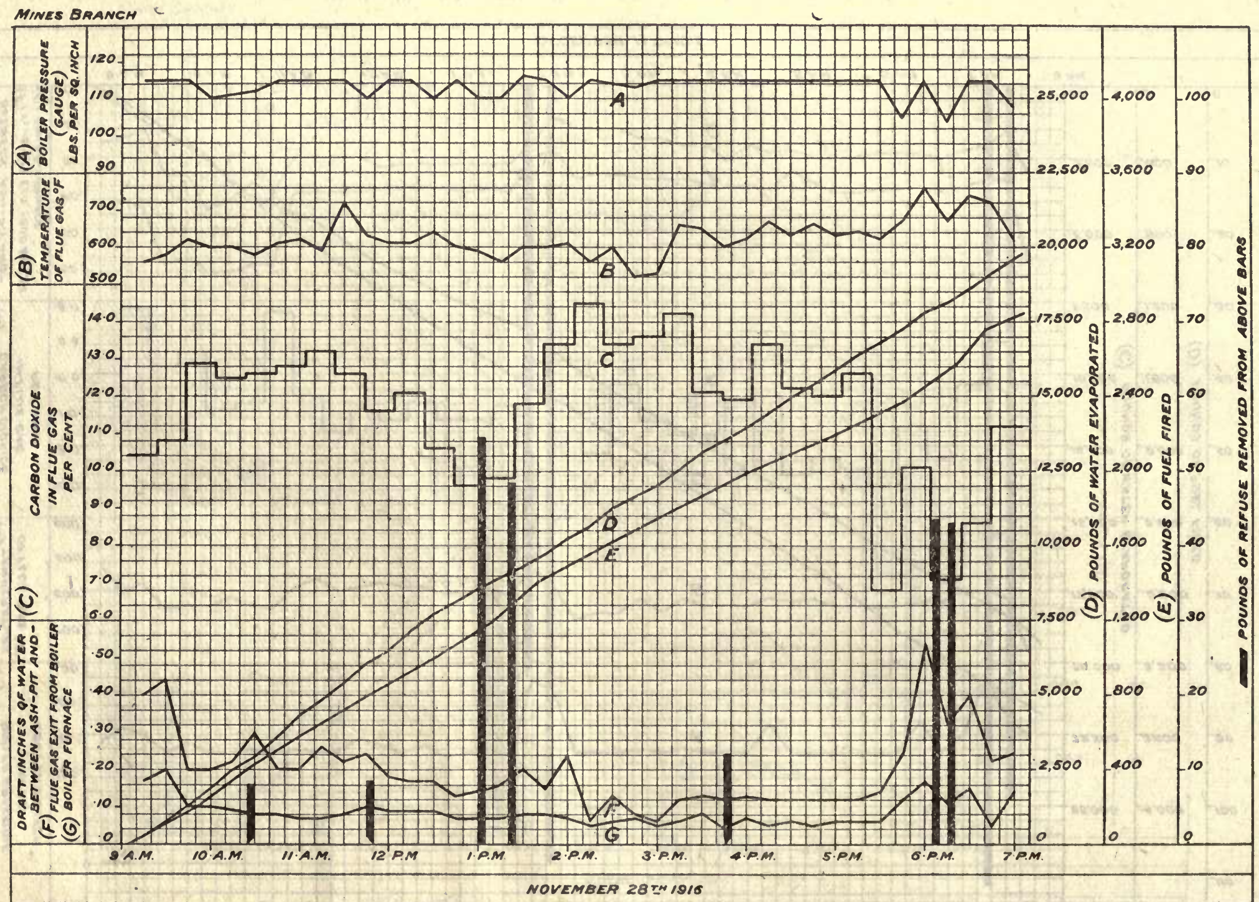


Boiler Trial No. 75: Fuel—Jasper Park Collieries, Ltd.

Chart No. 3.

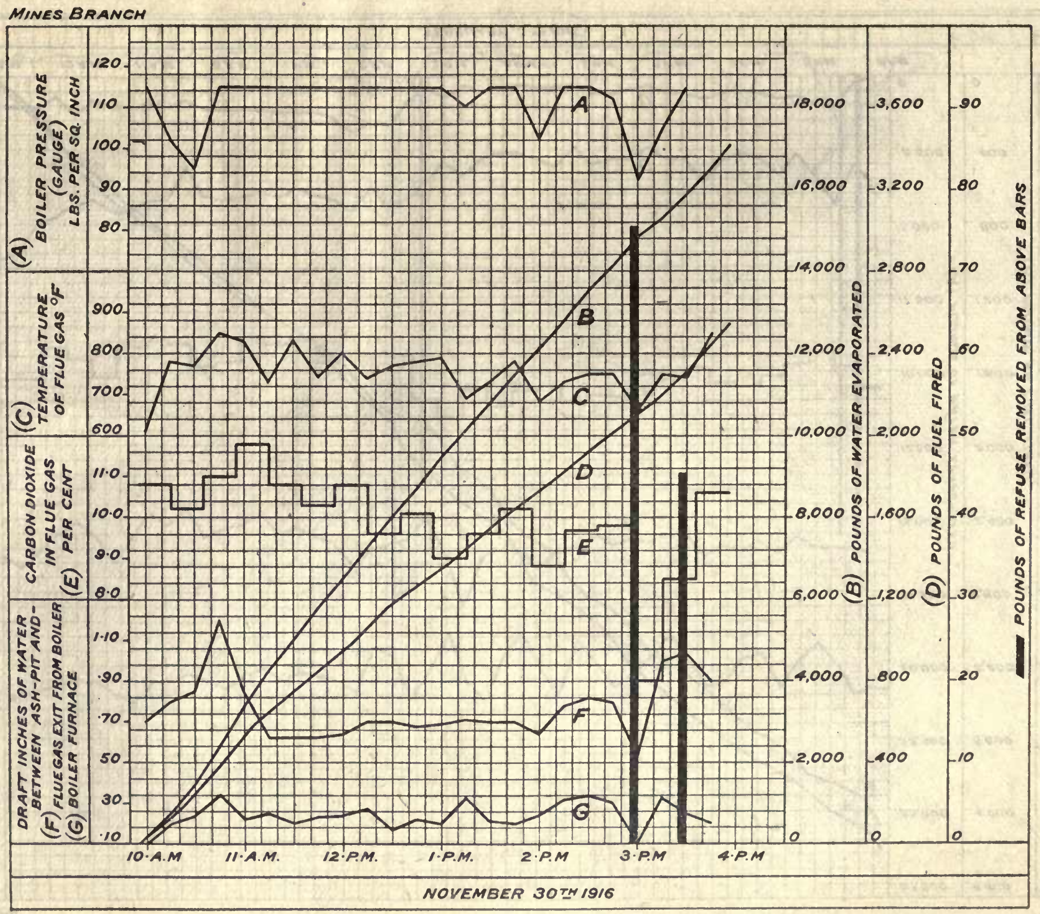
Boiler Trial No. 113: Fuel—Mountain Park Collieries, Ltd.

Chart No. 4.



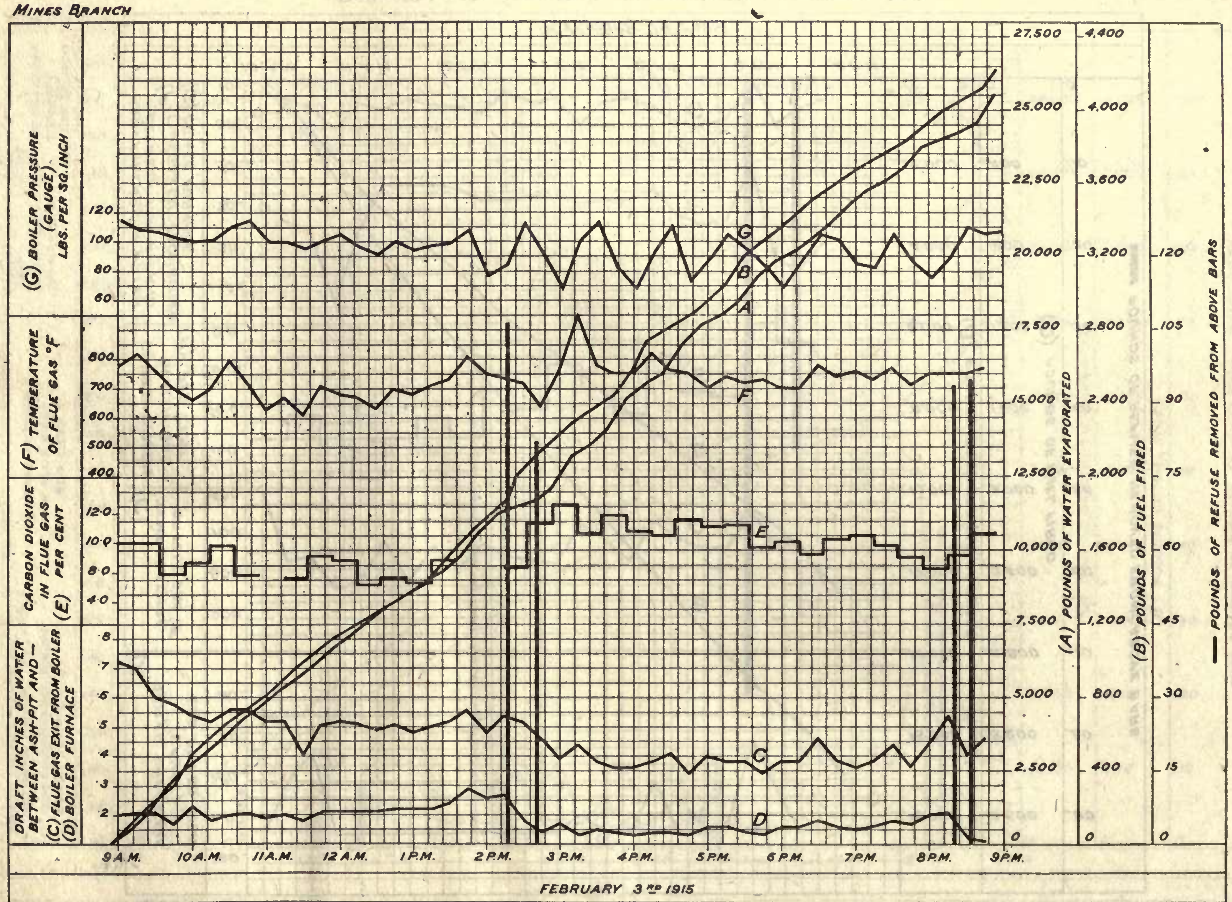
Boiler Trial No. 107: Fuel—Mountain Park Collieries, Ltd.

Chart No. 5.



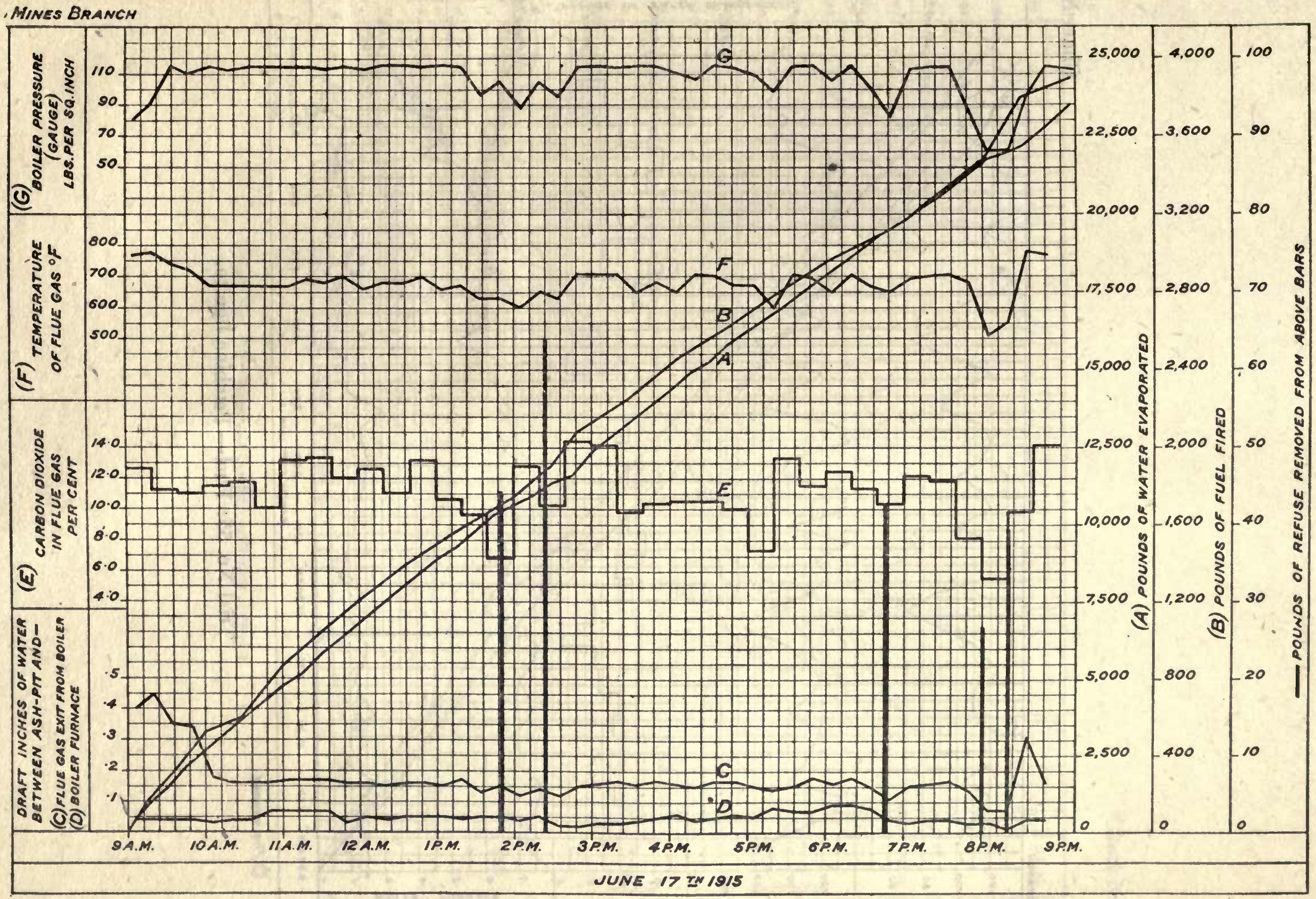
Boiler Trial No. 108: Fuel—Mountain Park Collieries, Ltd.

Chart No. 6.



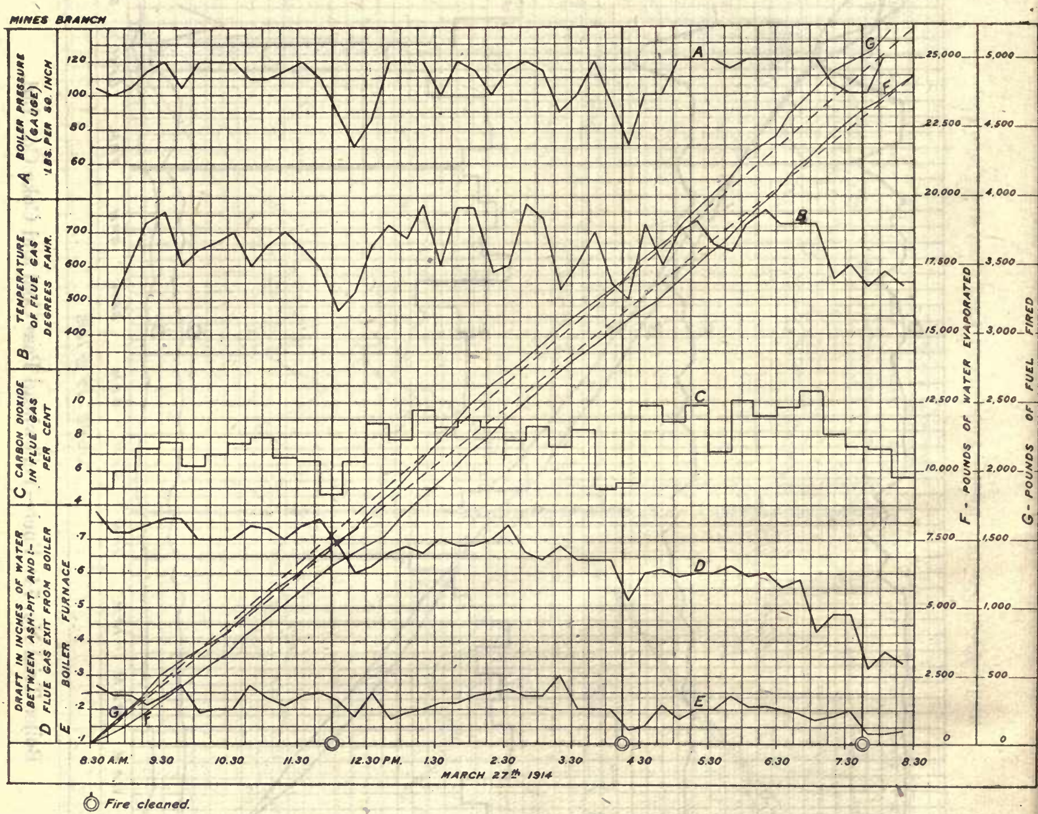
Boiler Trial No. 60: Fuel—Yellowhead Pass Coal and Coke Co.

Chart No. 7.



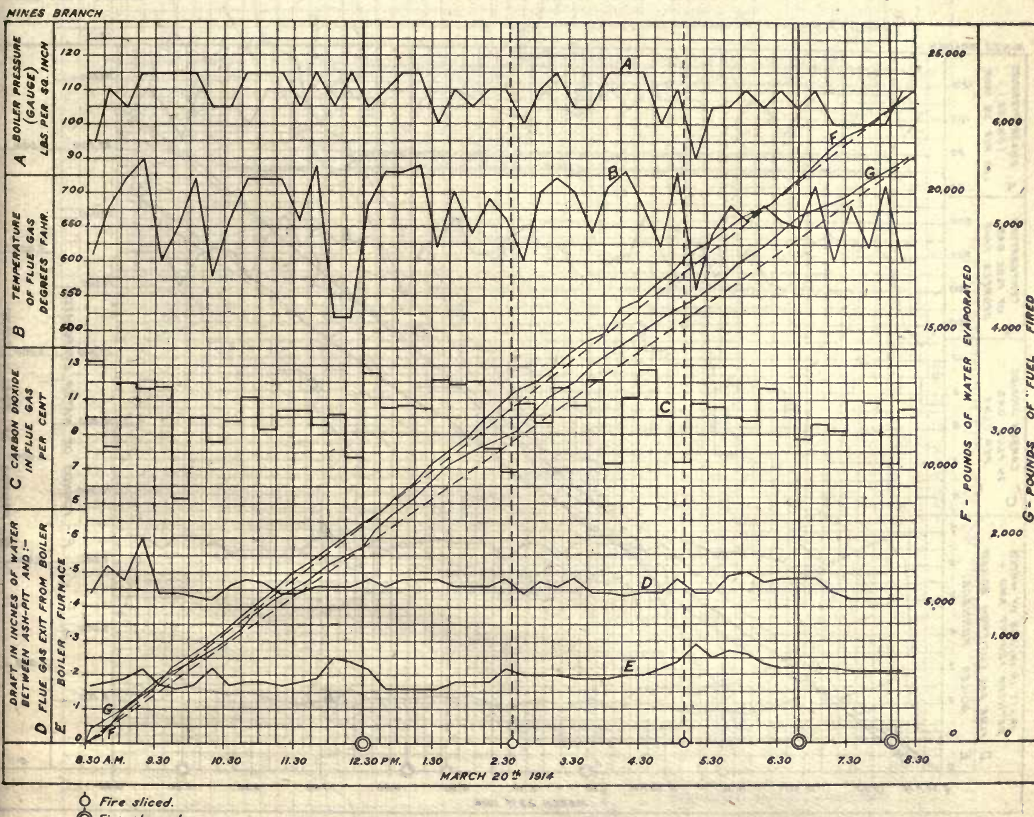
Boiler Trial No. 74: Fuel—Yellowhead Pass Coal and Coke Co., Ltd.

Chart No. 8.



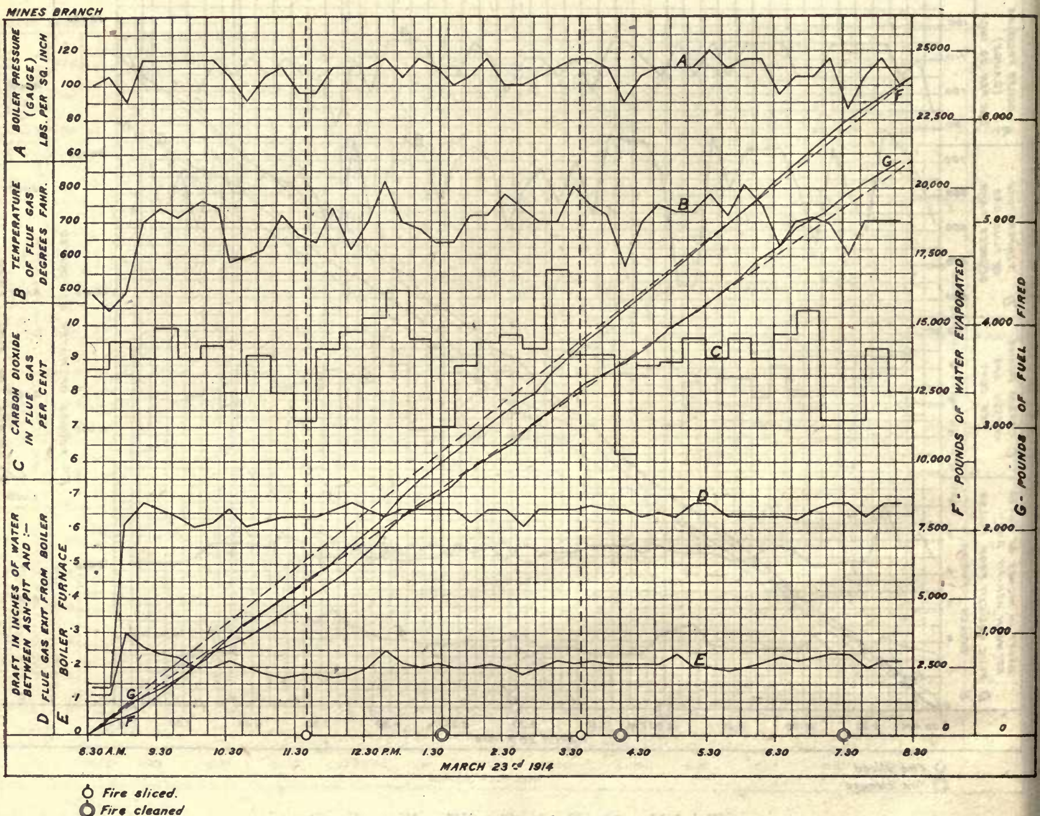
Trial No. 55: Fuel— Pembina lignite.

Chart No. 9.



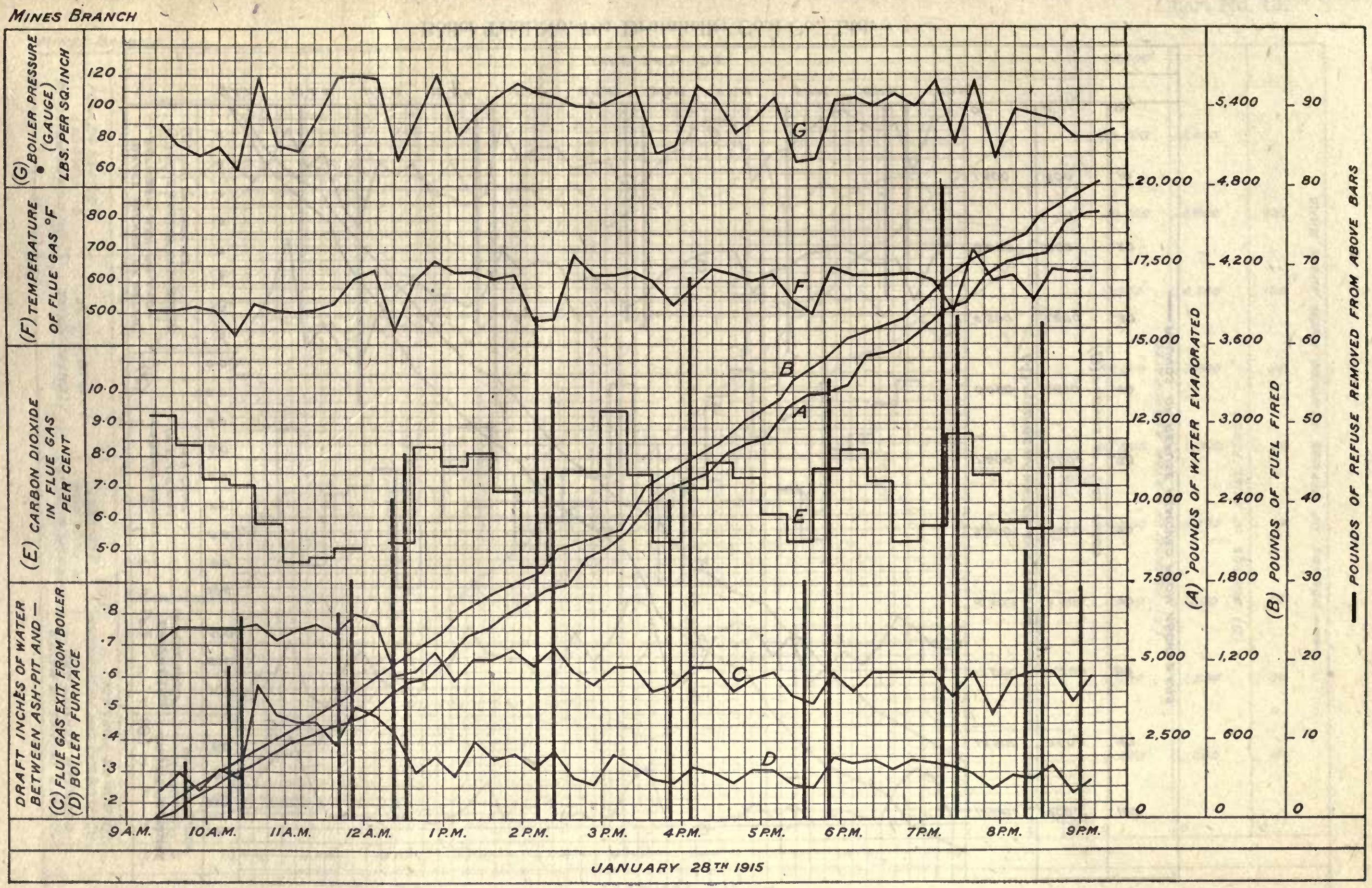
Trial No. 52: Fuel—Cardiff colliery lignite.

Chart No. 10.



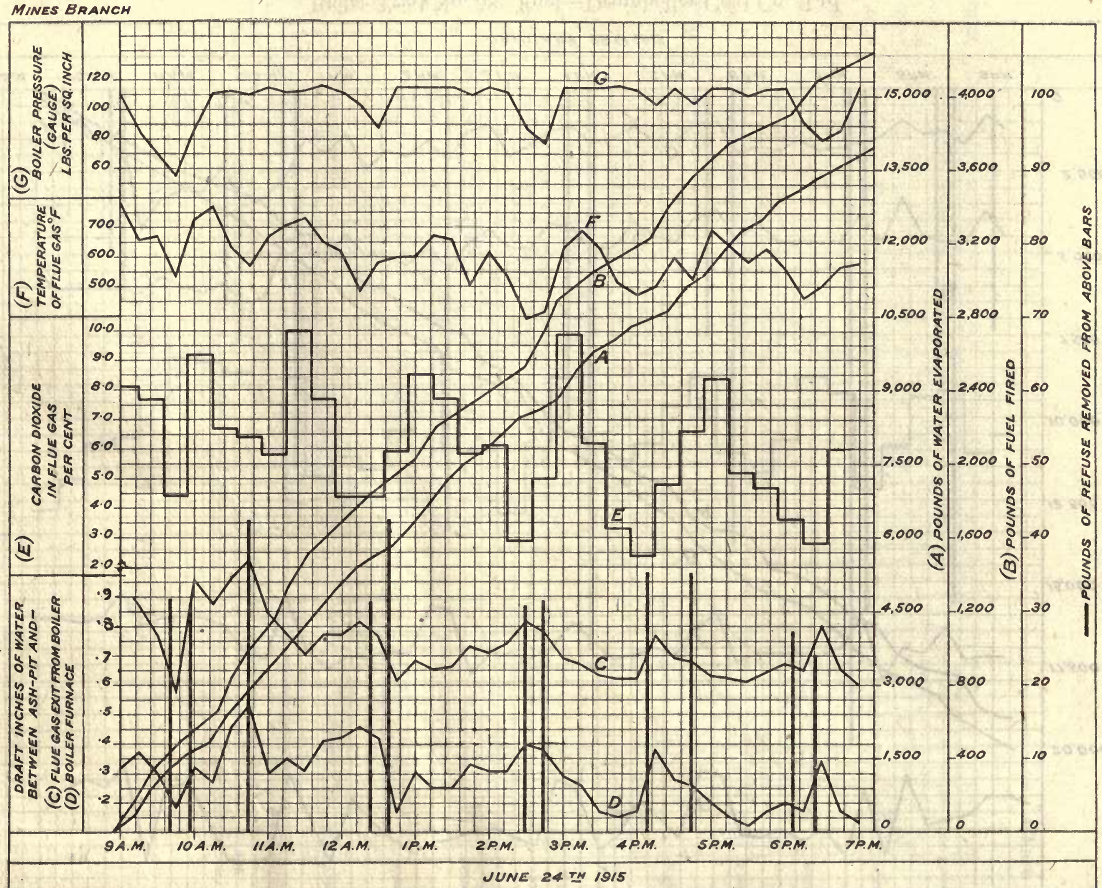
Trial No. 53: Fuel—Twin City lignite.

Chart No. 11.



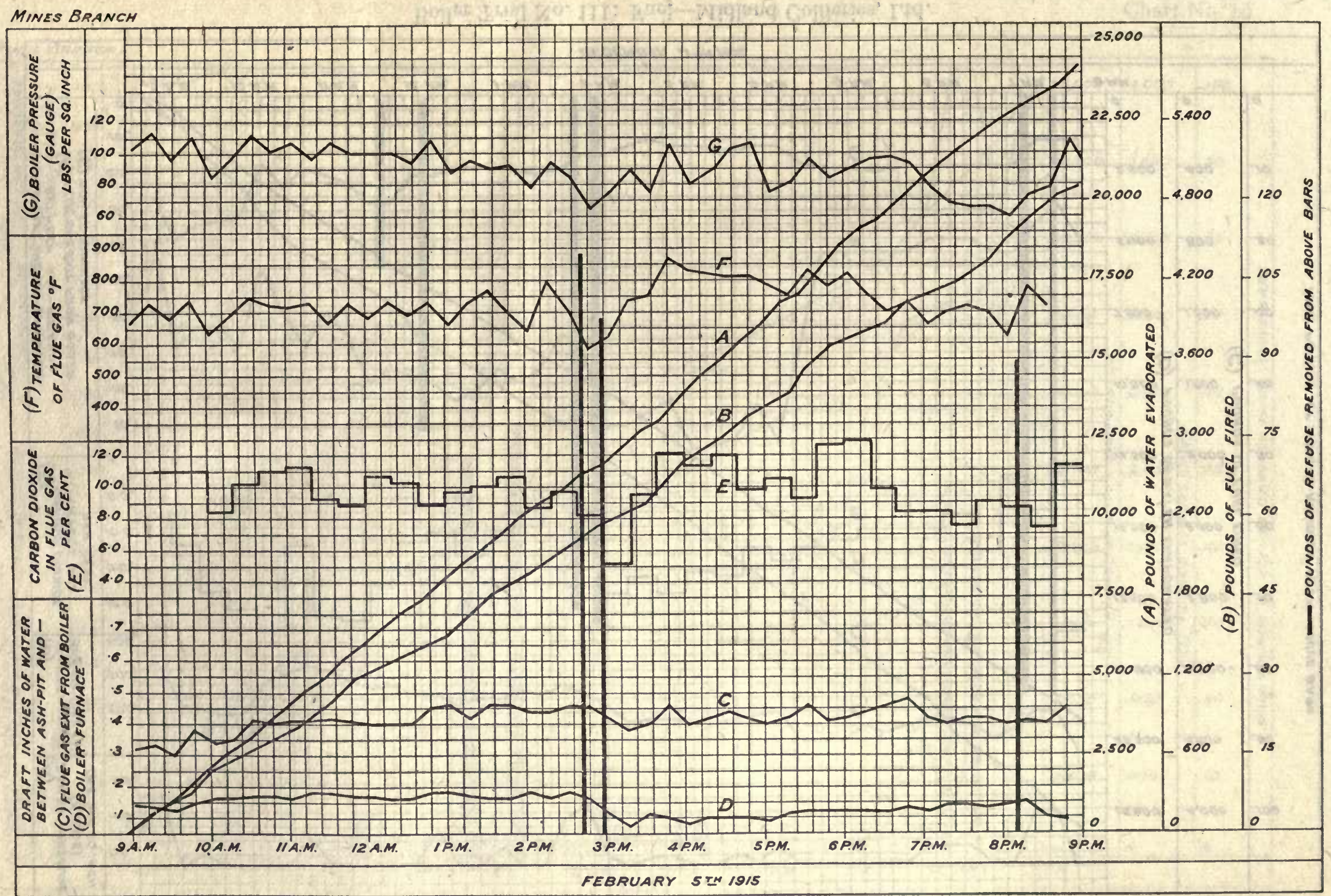
Boiler Trial No. 58: Fuel—Drumheller Coal Co., Ltd.

Chart No. 12.



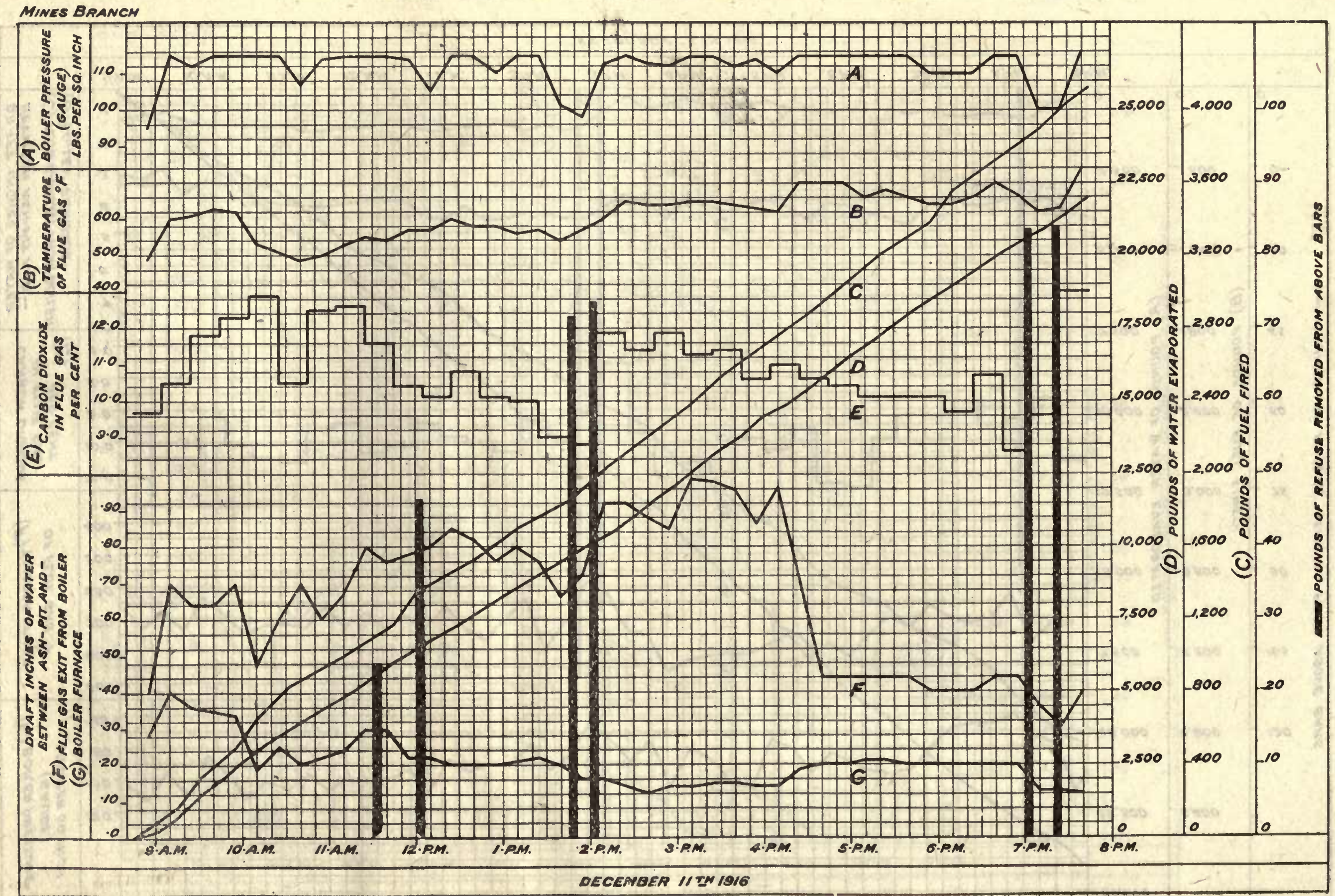
Boiler Trial No. 76: Drumheller Coal Co., Ltd.

Chart No. 13.



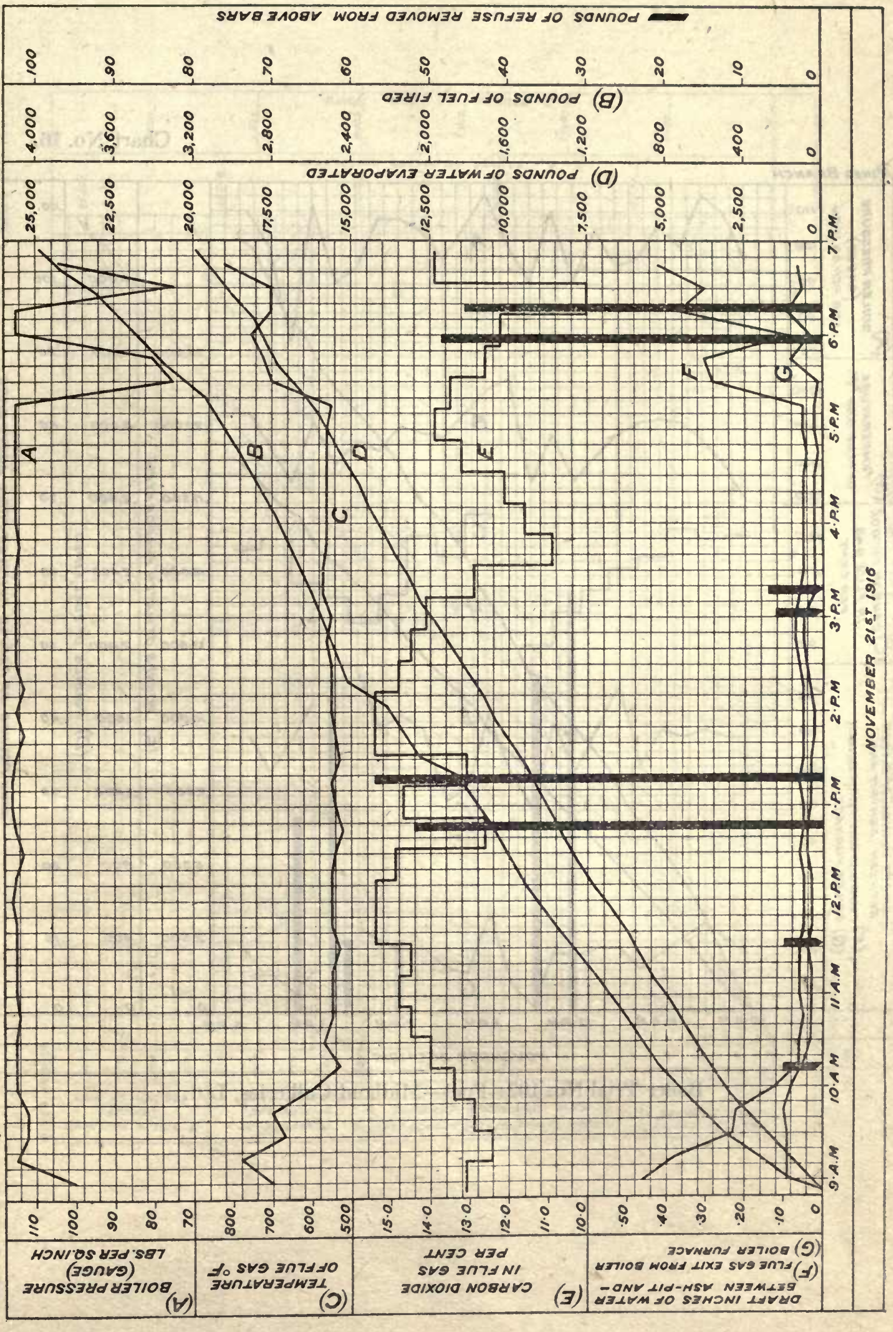
Boiler Trial No. 61: Fuel—Newcastle Coal Co., Ltd.

Chart No. 14.



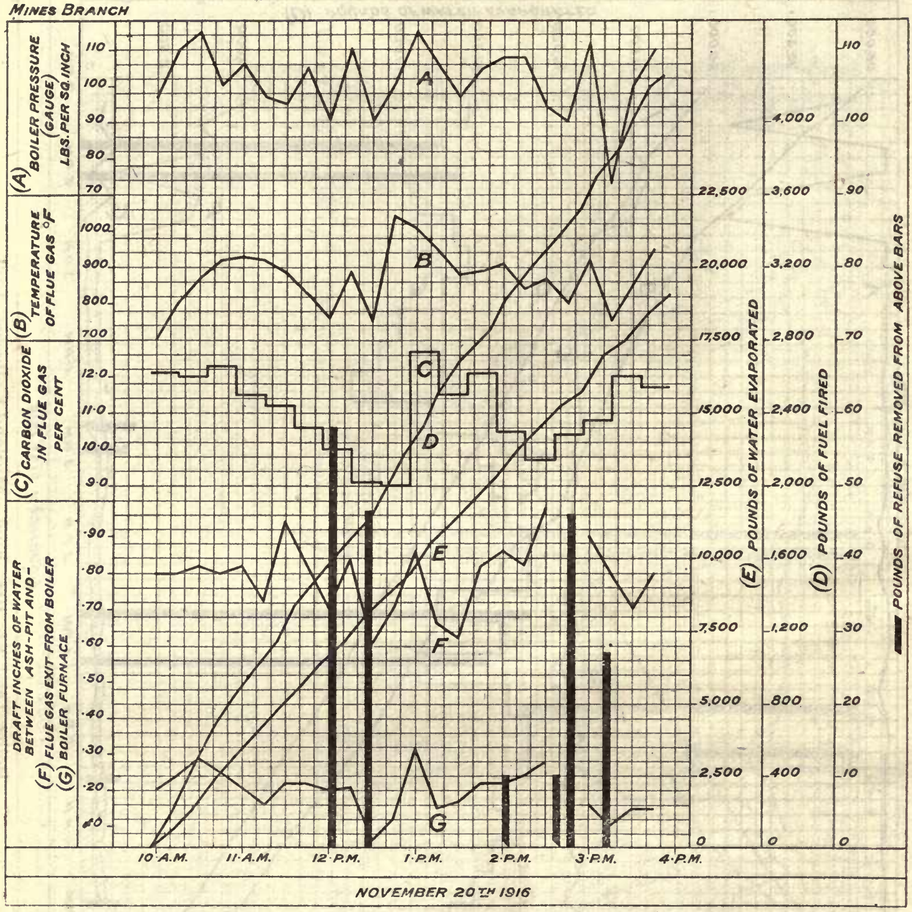
Boiler Trial No. 111: Fuel—Midland Collieries, Ltd.

Chart No. 15.



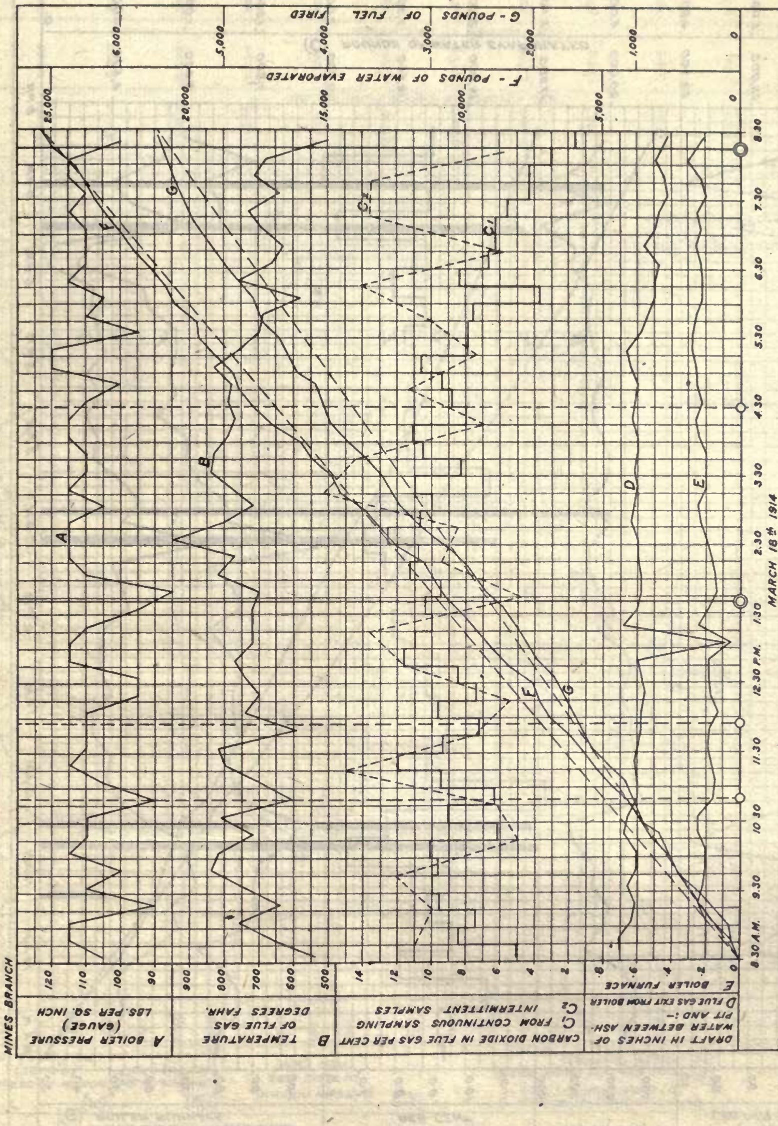
Boiler Trial No. 103: Fuel—Midland Collieries, Ltd.

Chart No. 16.



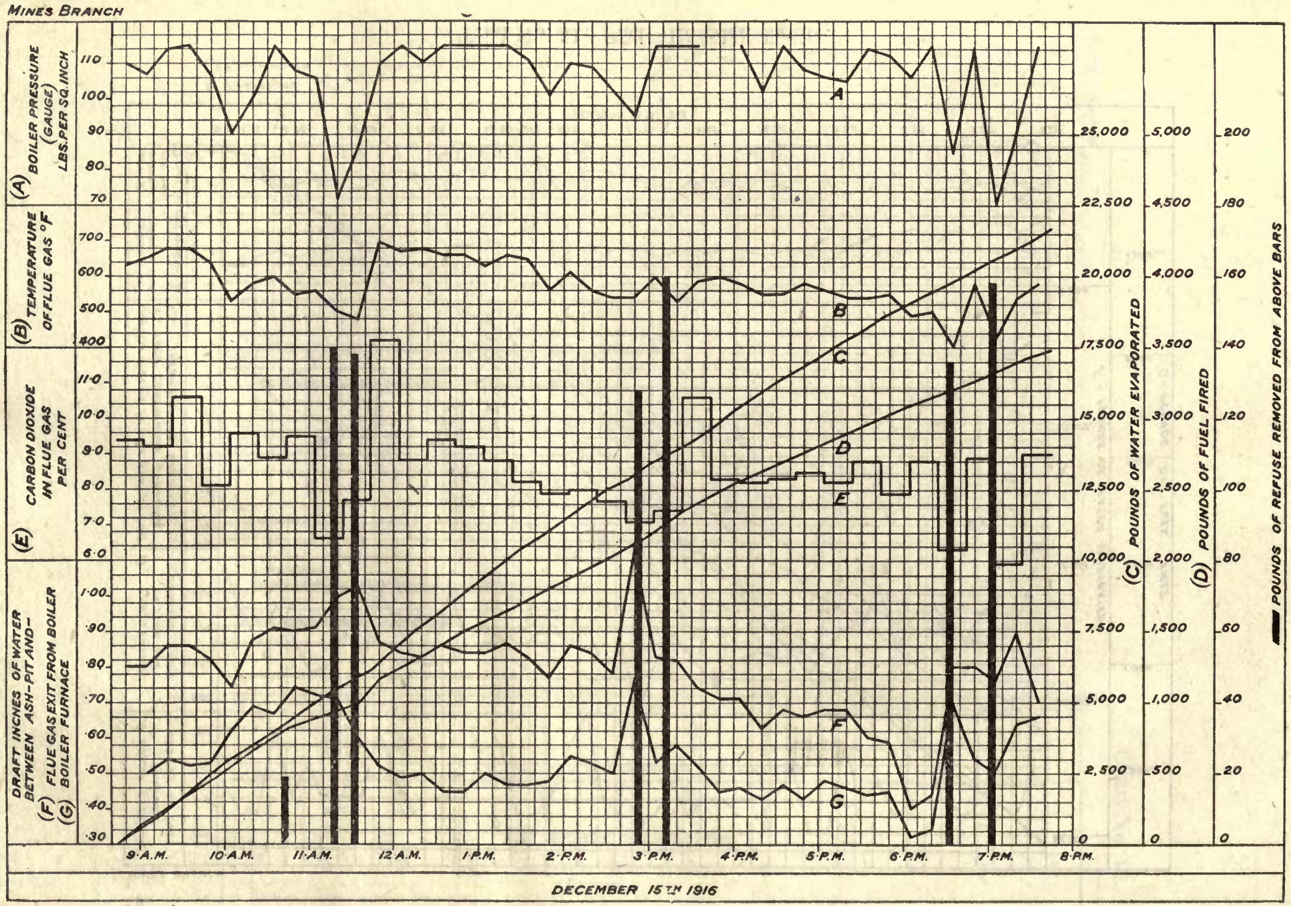
Boiler Trial No. 102: Fuel—Midland Collieries, Ltd.

Chart No. 17.



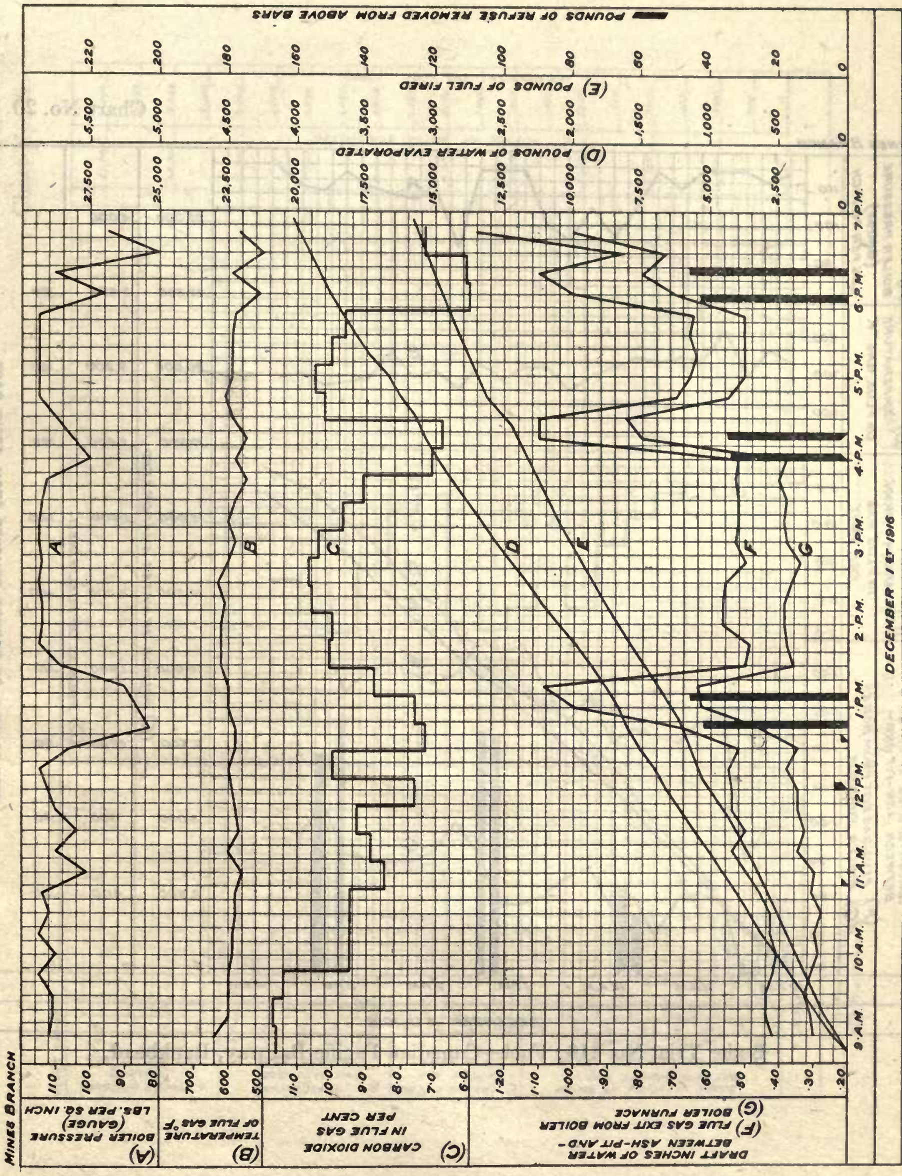
Trial No. 51: Fuel—Rosedale lignite.

Chart No. 18.



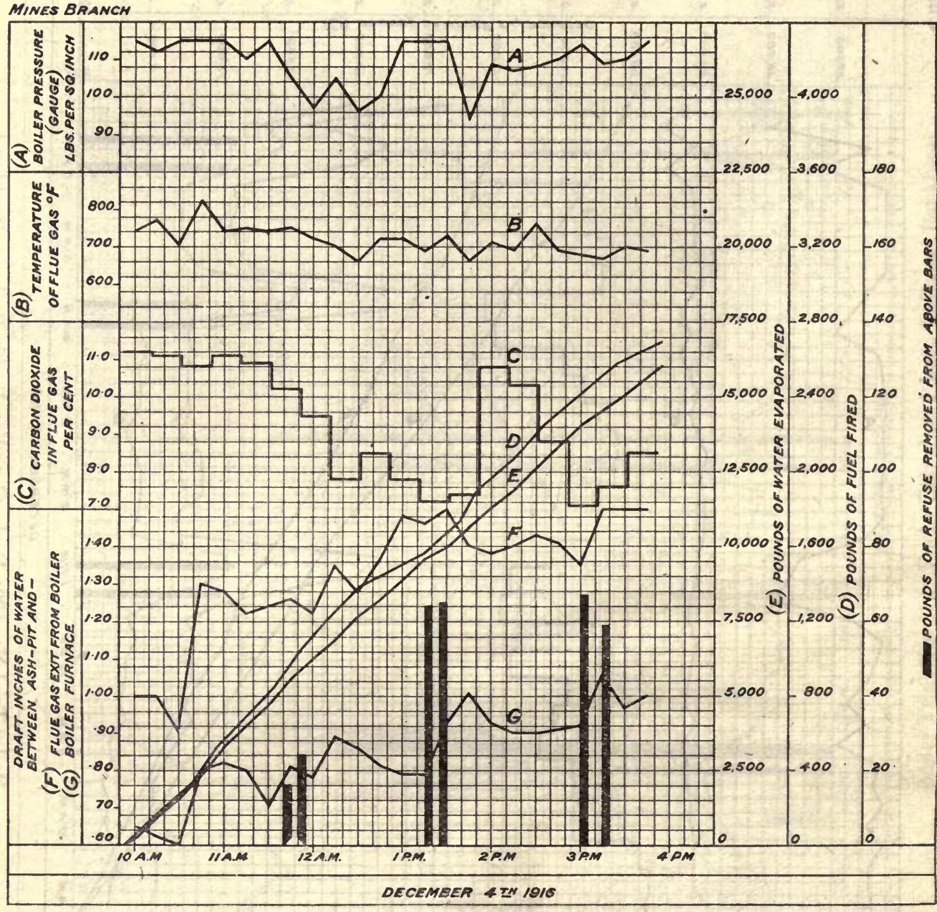
Boiler Trial No. 114: Fuel—Canadian Pacific Railway, Bankhead.

Chart No. 19.



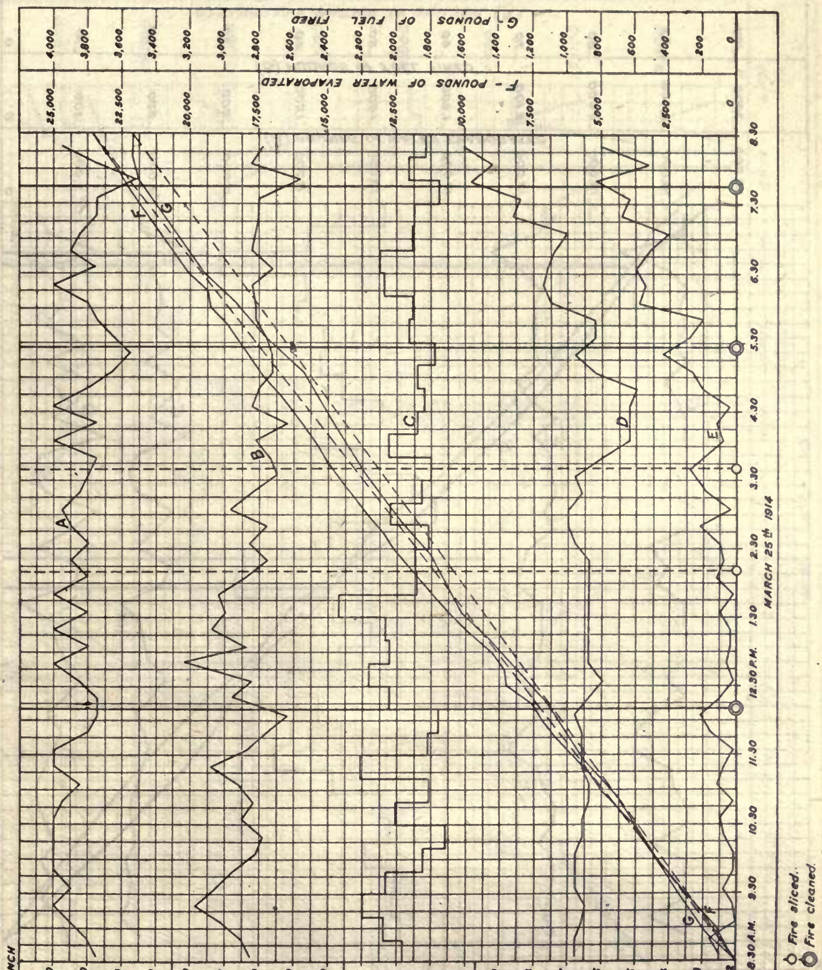
Boiler Trial No. 109: Fuel—Canadian Pacific Railway, Bankhead.

Chart No. 20.



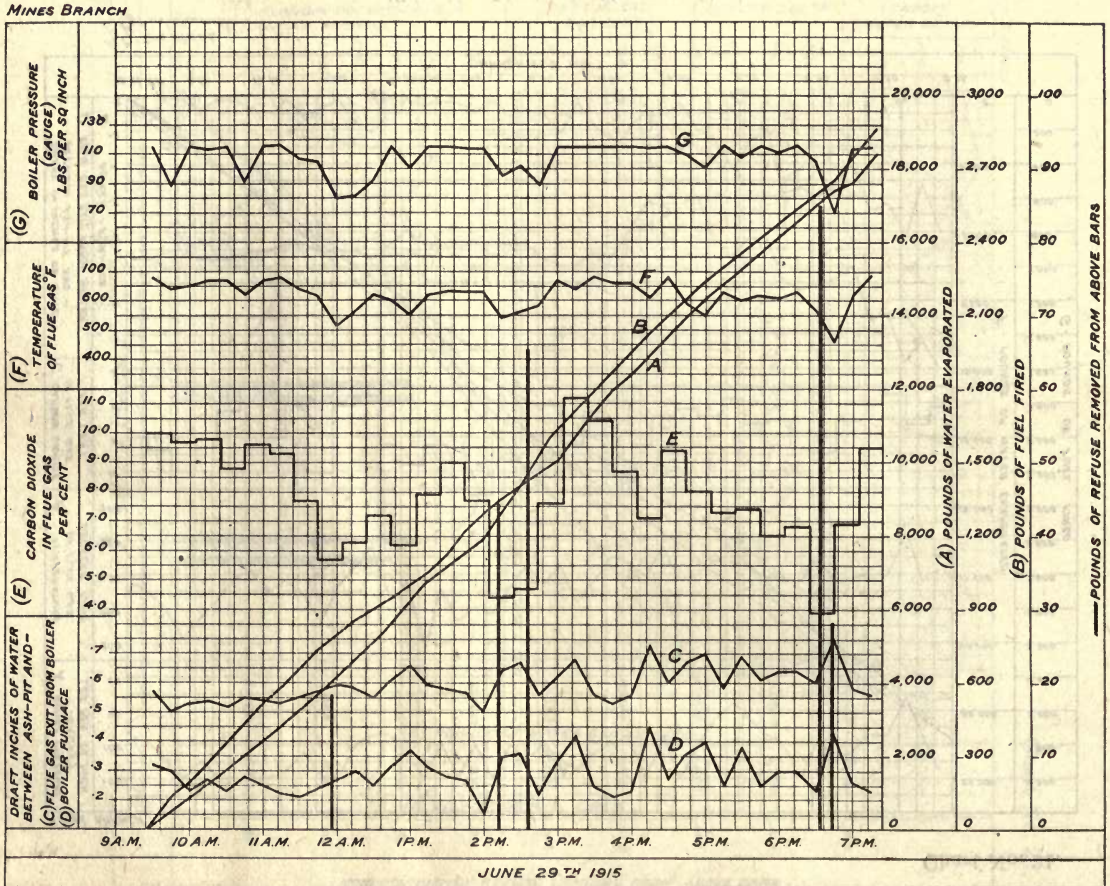
Boiler Trial No. 110: Fuel—Canadian Pacific Railway, Bankhead.

Chart No. 21.



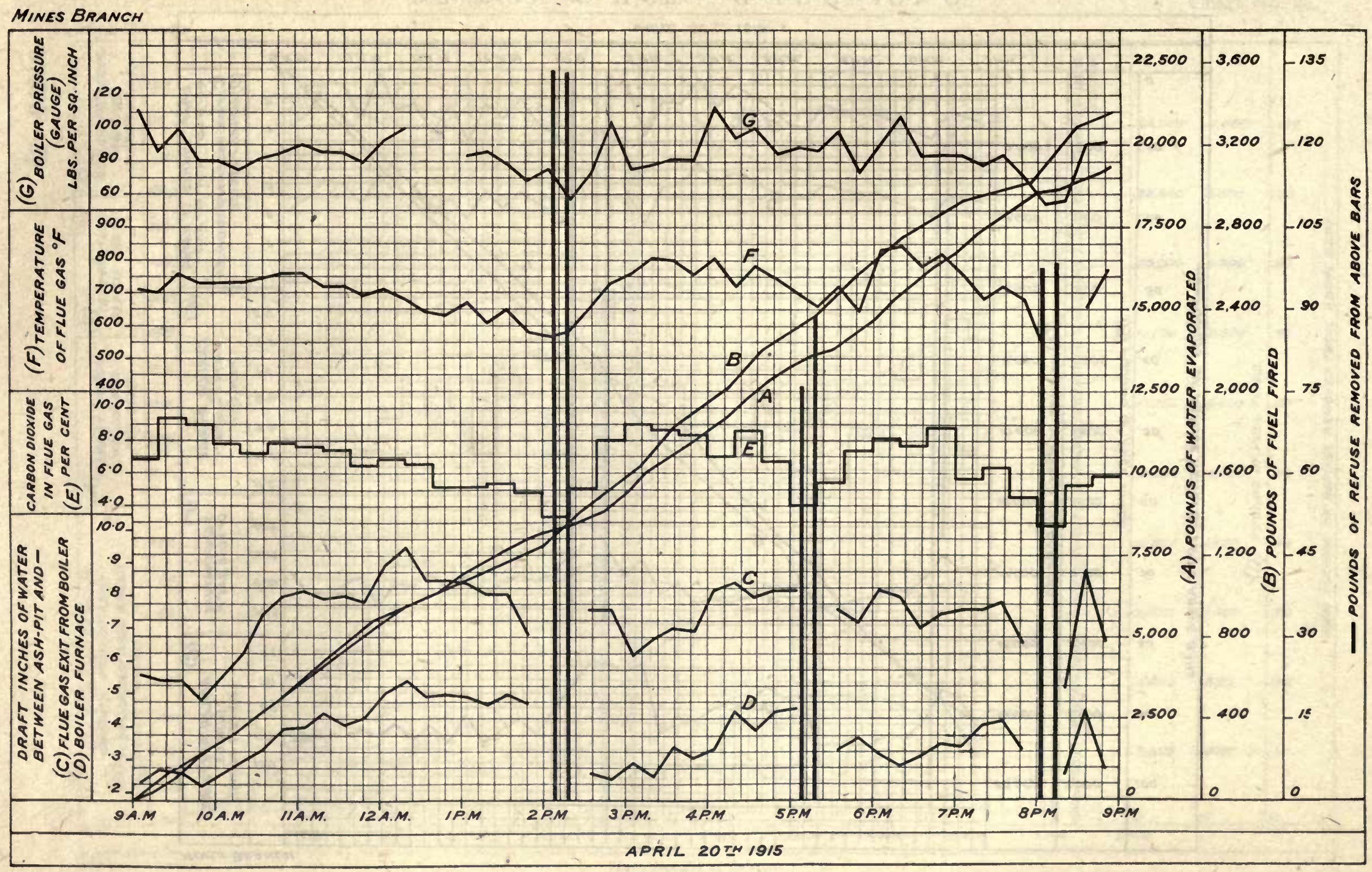
Trial No. 54: Fuel—Canmore Coal.

Chart No. 22.



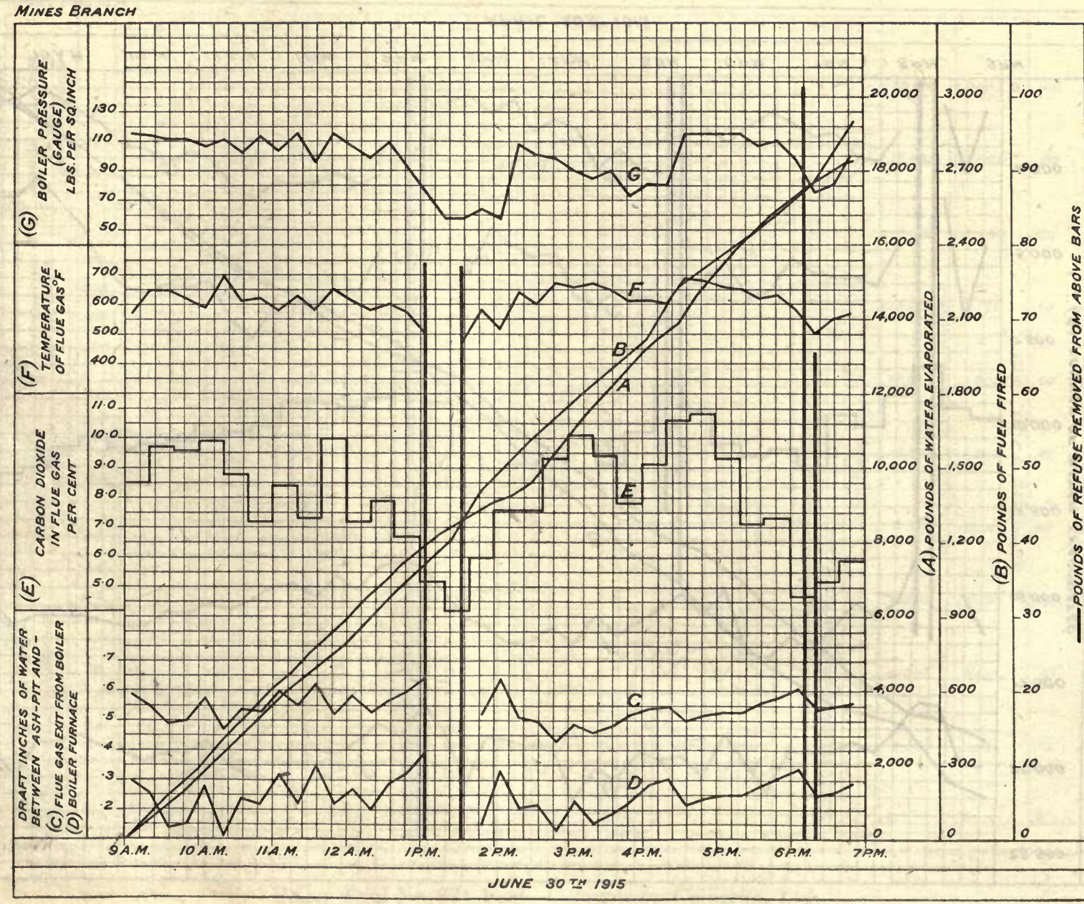
Boiler Trial No. 77: Fuel—Georgetown Collieries, Ltd.

Chart No. 23.



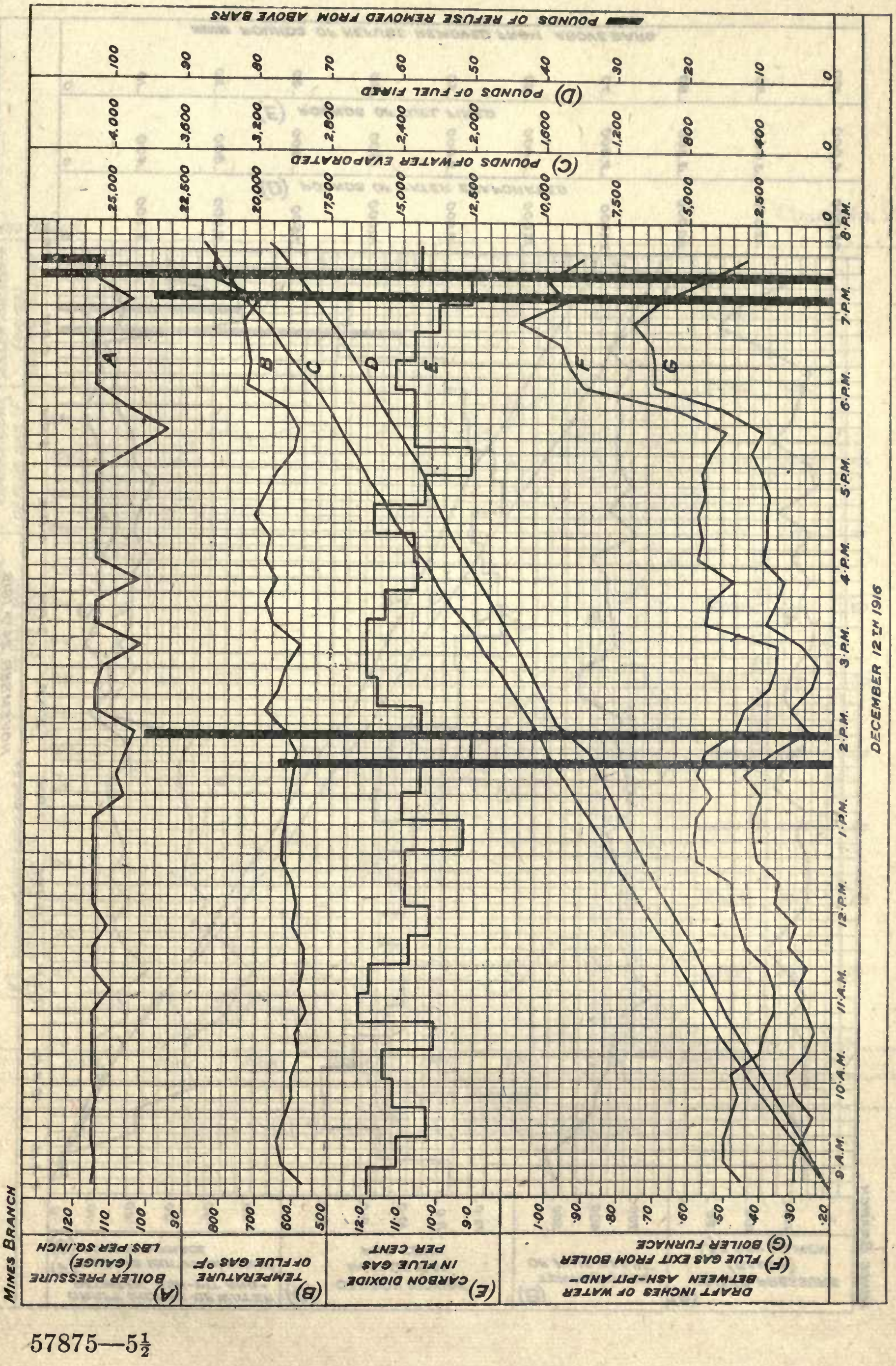
Boiler Trial No. 69: Fuel—McGillivray Creek Coal and Coke Co.

Chart No. 24.



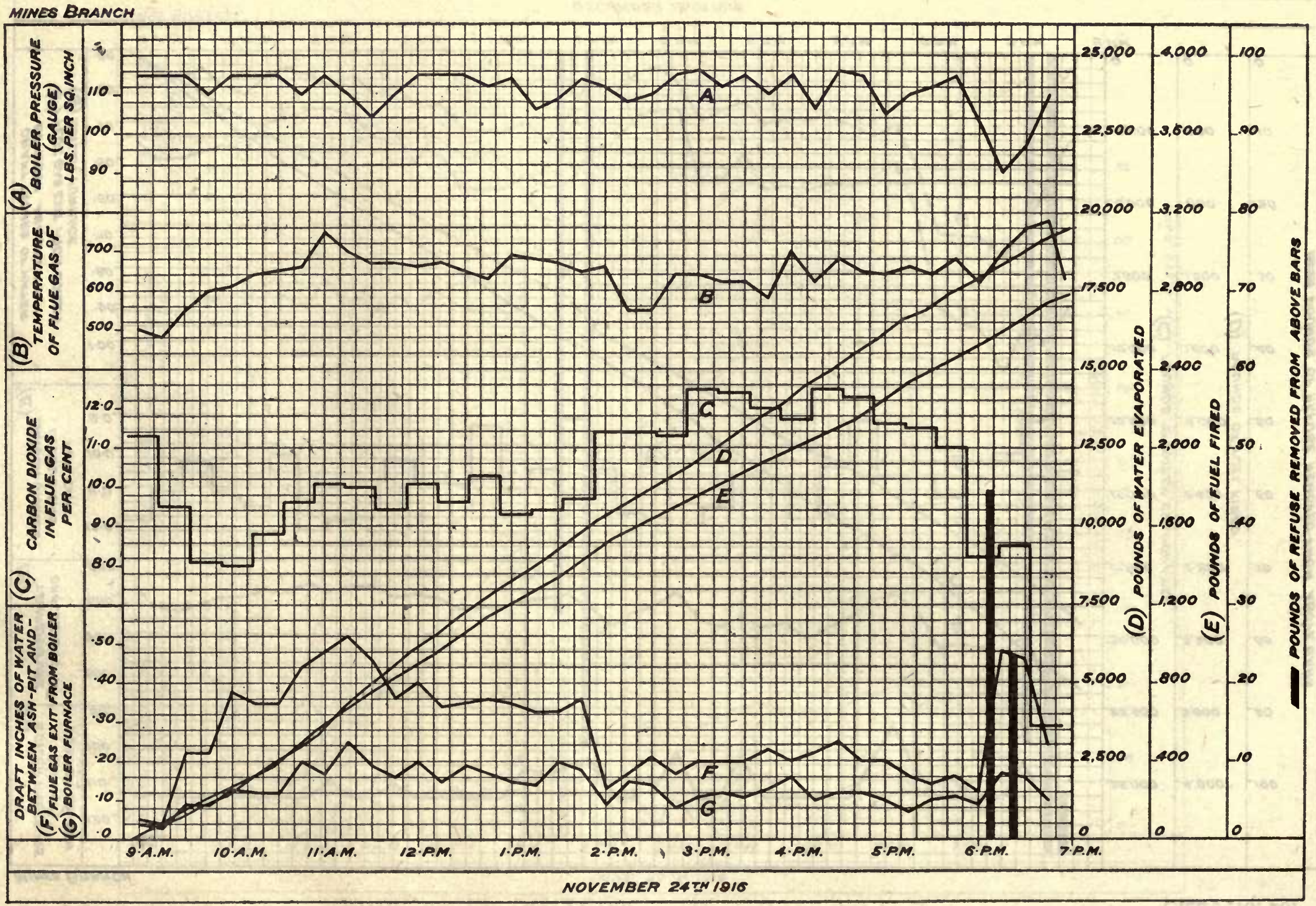
Boiler Trial No. 78: McGillivray Creek Coal and Coke Co.

Chart No. 25.



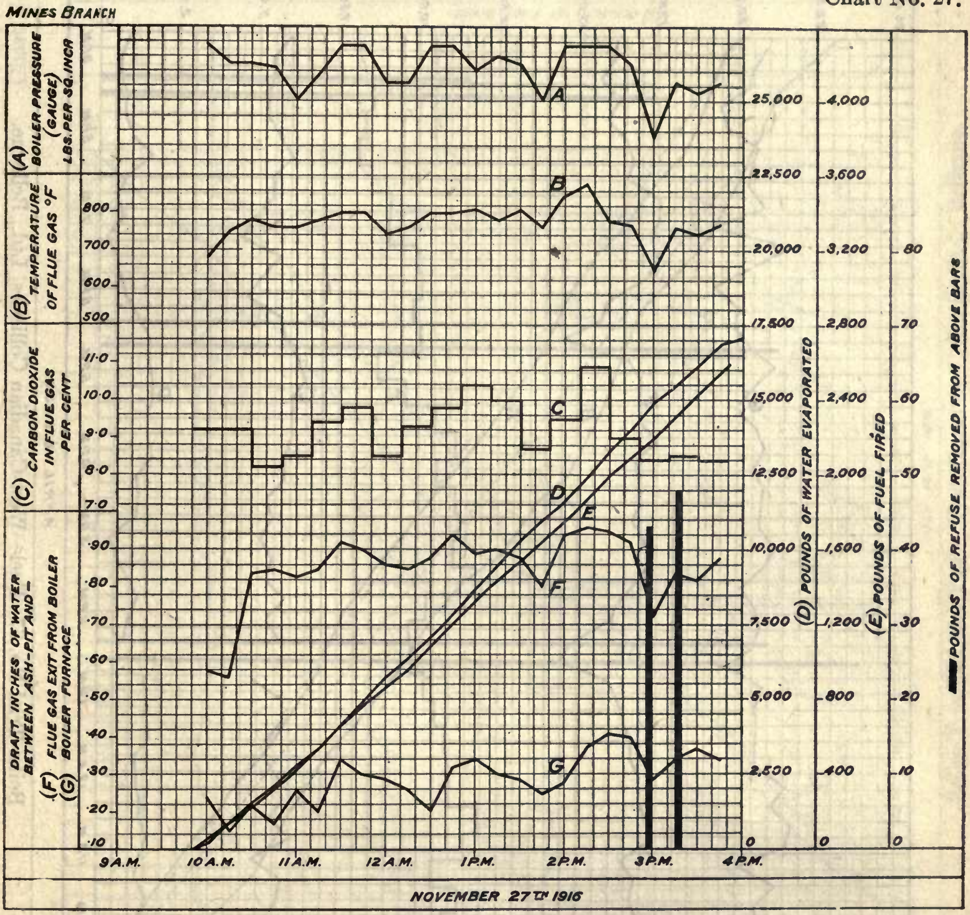
Boiler Trial No. 112: Fuel—Hillcrest Collieries, Ltd.

Chart No. 26.



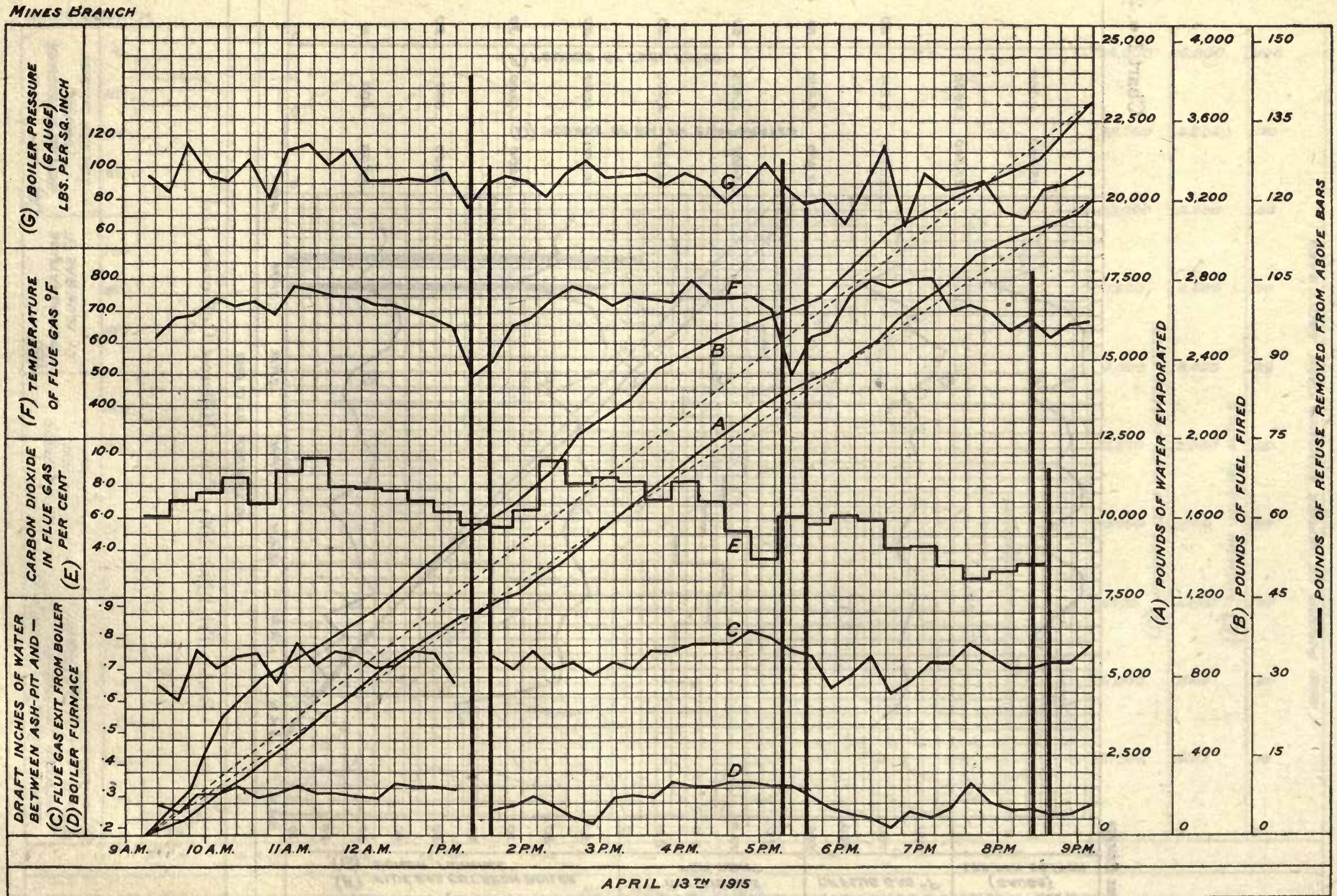
Boiler Trial No. 105: Fuel—Hillcrest Collieries, Ltd.

Chart No. 27.



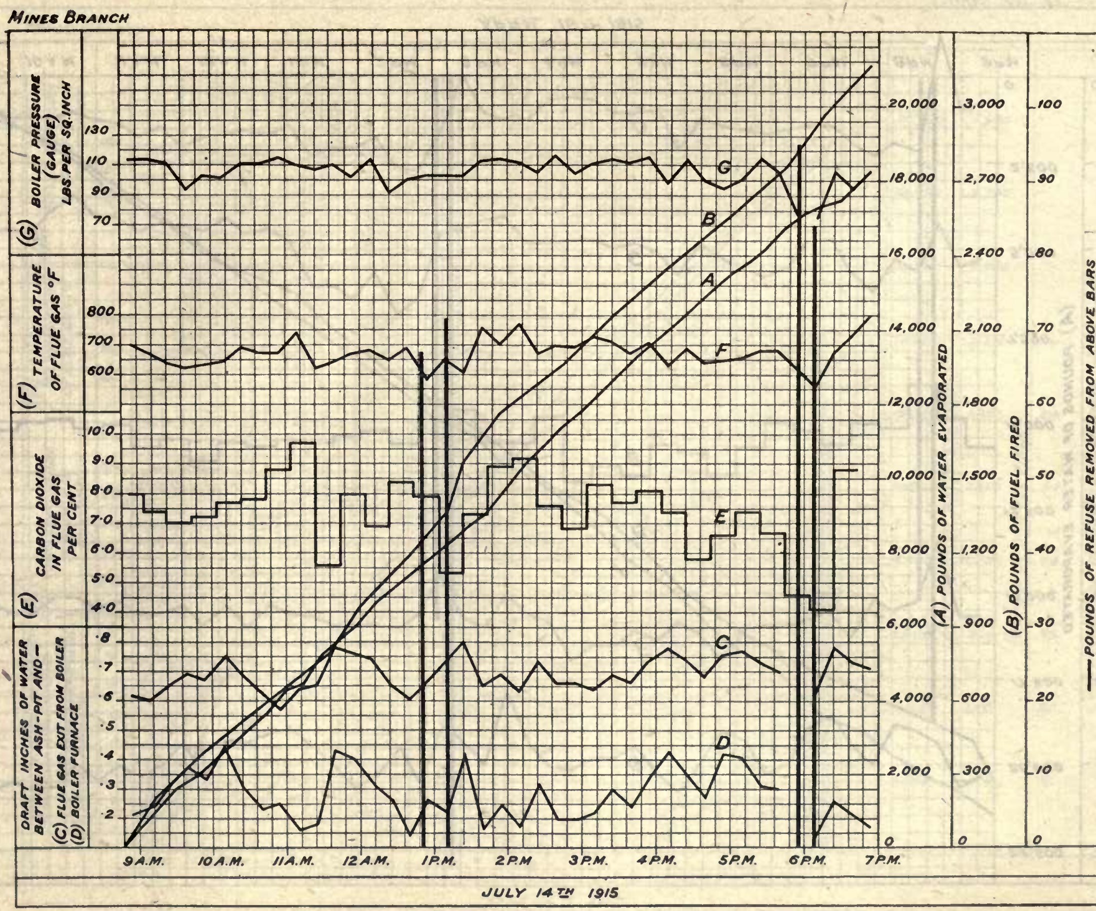
Boiler Trial No. 106: Fuel—Hillcrest Collieries, Ltd.

Chart No. 28.



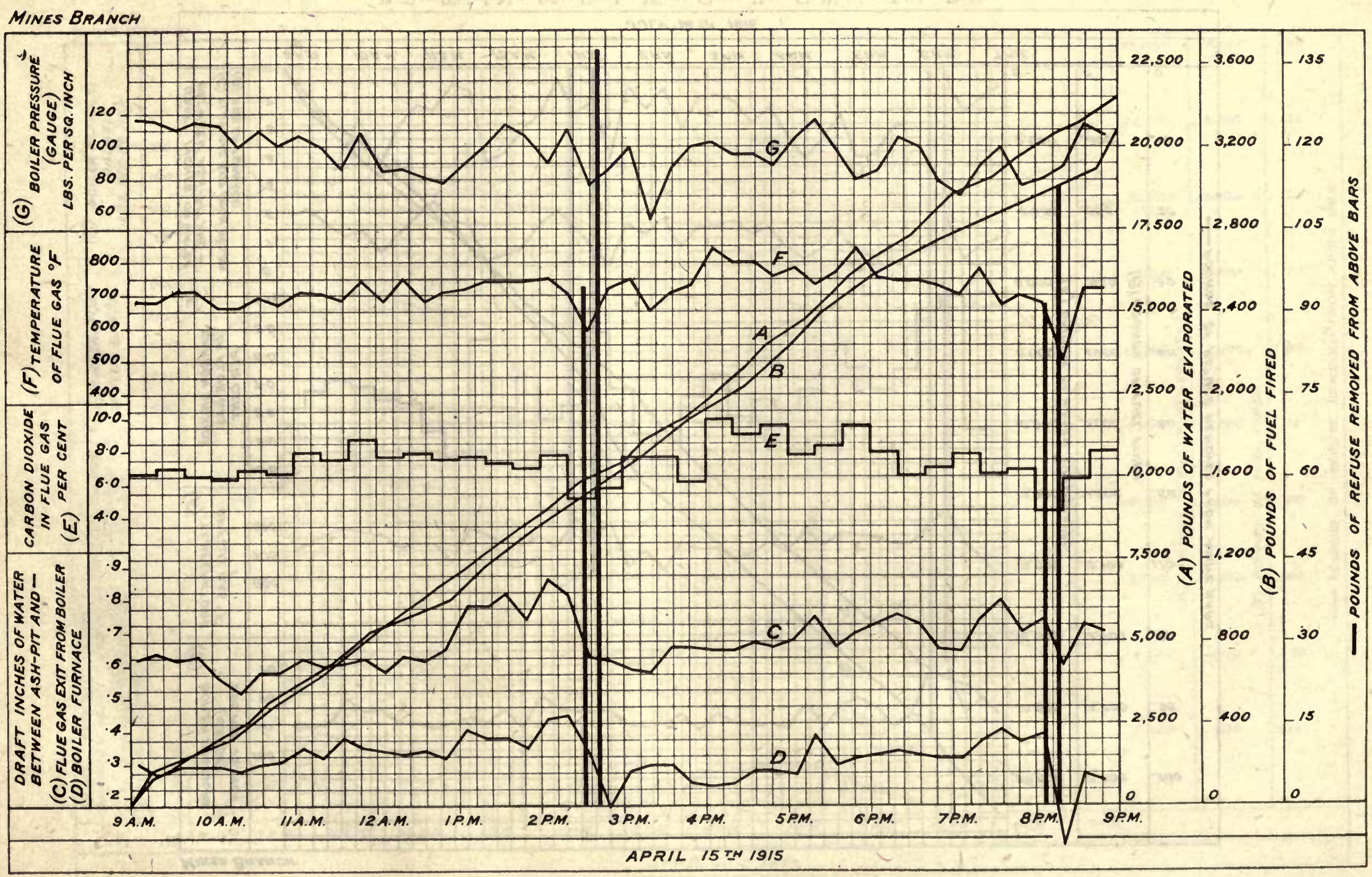
Boiler Trial No. 67: Fuel—West-Canadian Collieries, Ltd., Bellevue.

Chart No. 29.



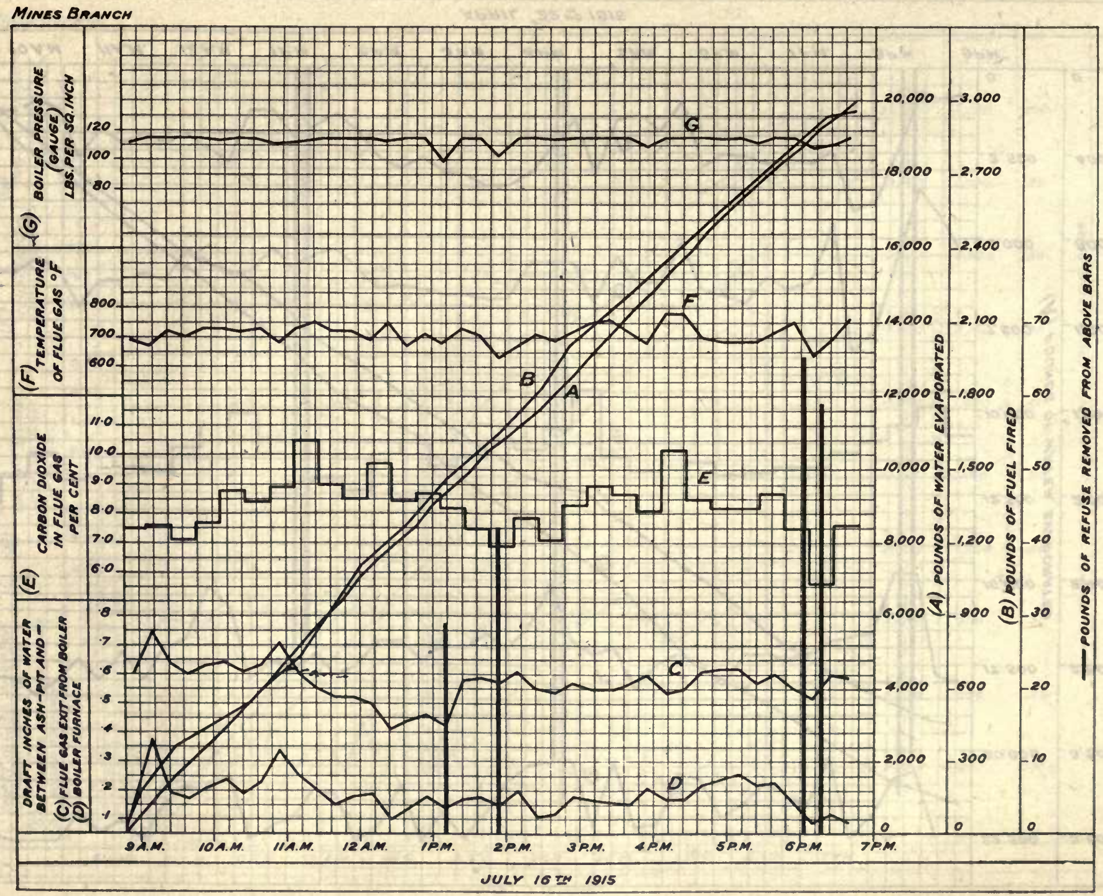
Boiler Trial No. 80: Fuel—West-Canadian Collieries Ltd., Bellevue.

Chart No. 30.



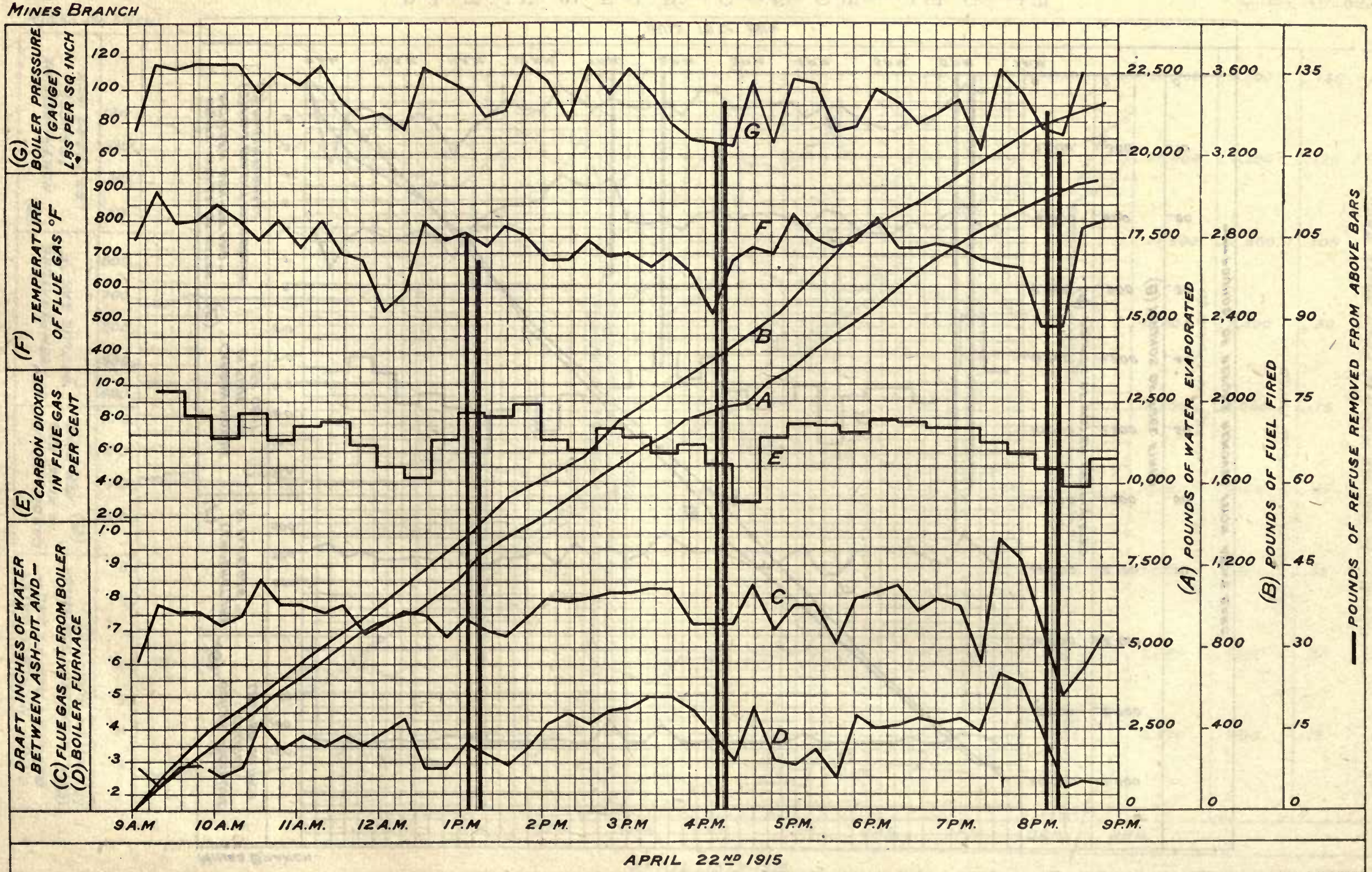
Boiler Trial No. 68: Fuel—West-Canadian Collieries Ltd., Greenhill.

Chart No. 31.



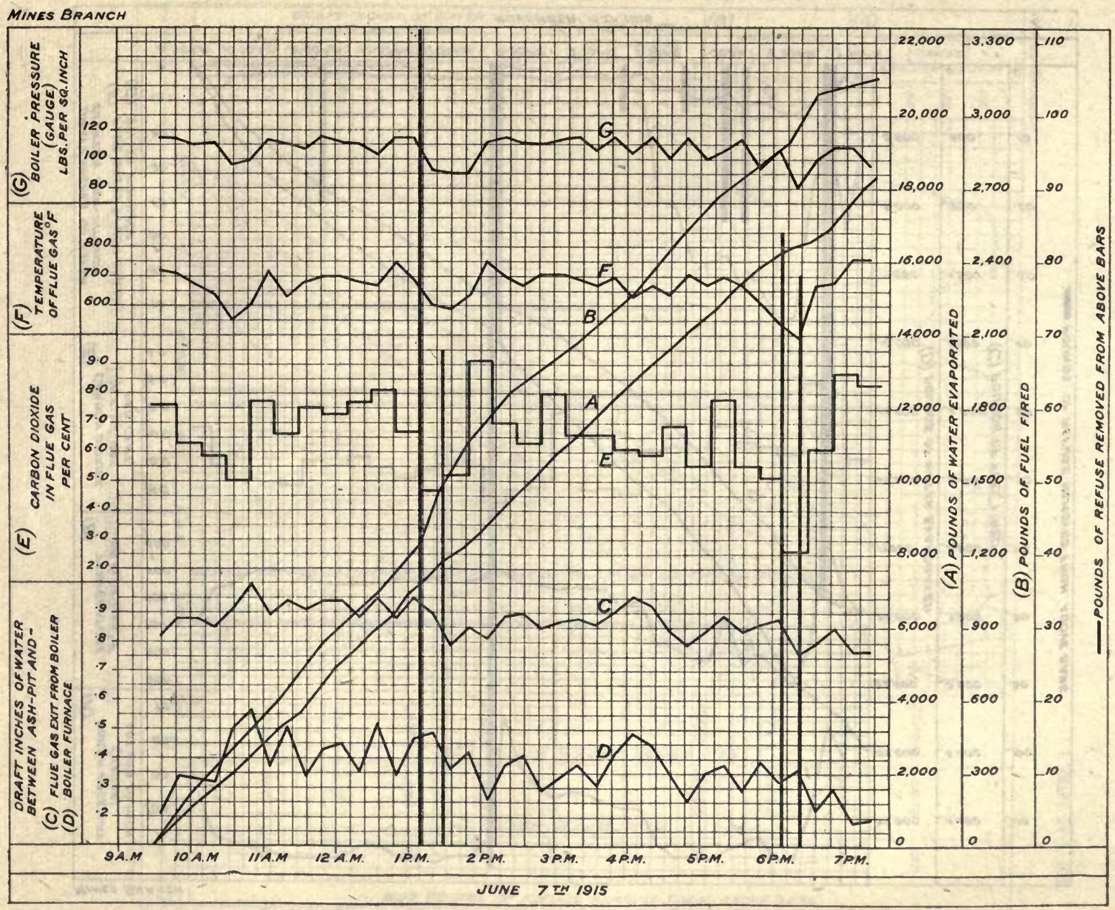
Boiler Trial No. 81: Fuel—West-Canadian Collieries Ltd., Greenhill.

Chart No. 32



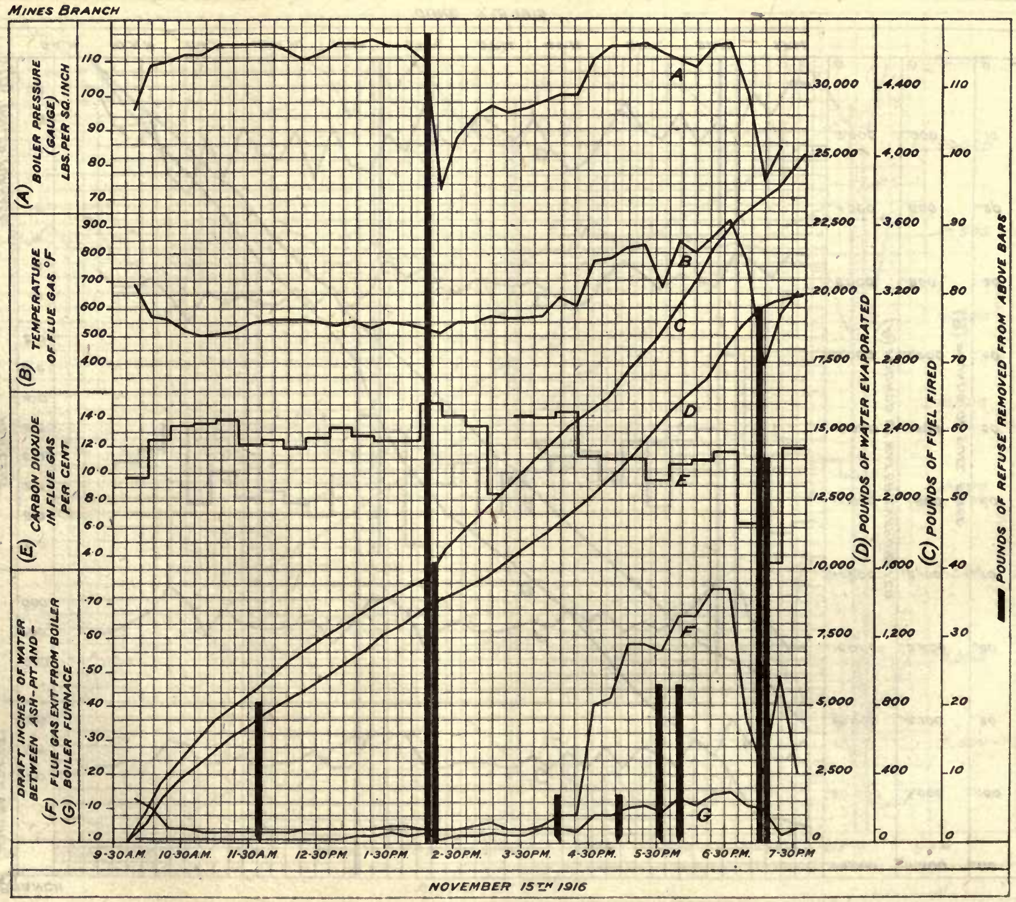
Boiler Trial No. 70: Fuel—Franco-Canadian Collieries, Ltd.

Chart No. 33.



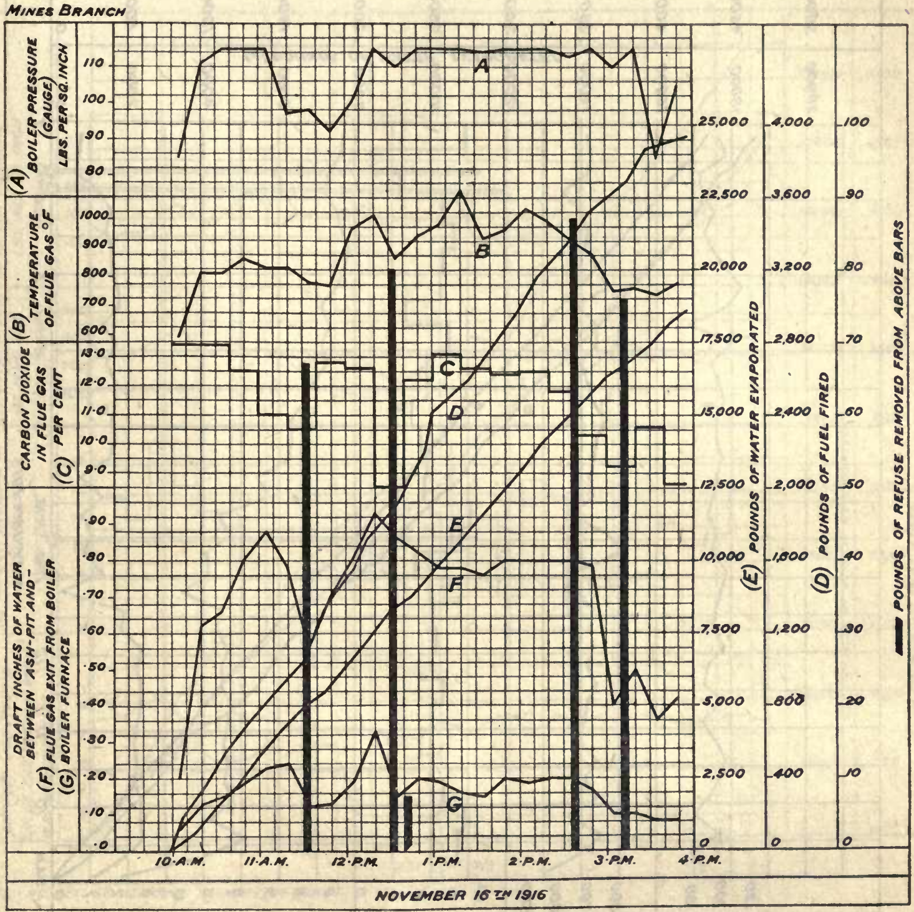
Boiler Trial No. 79: Fuel—Franco-Canadian Collieries, Ltd.

Chart No. 34.



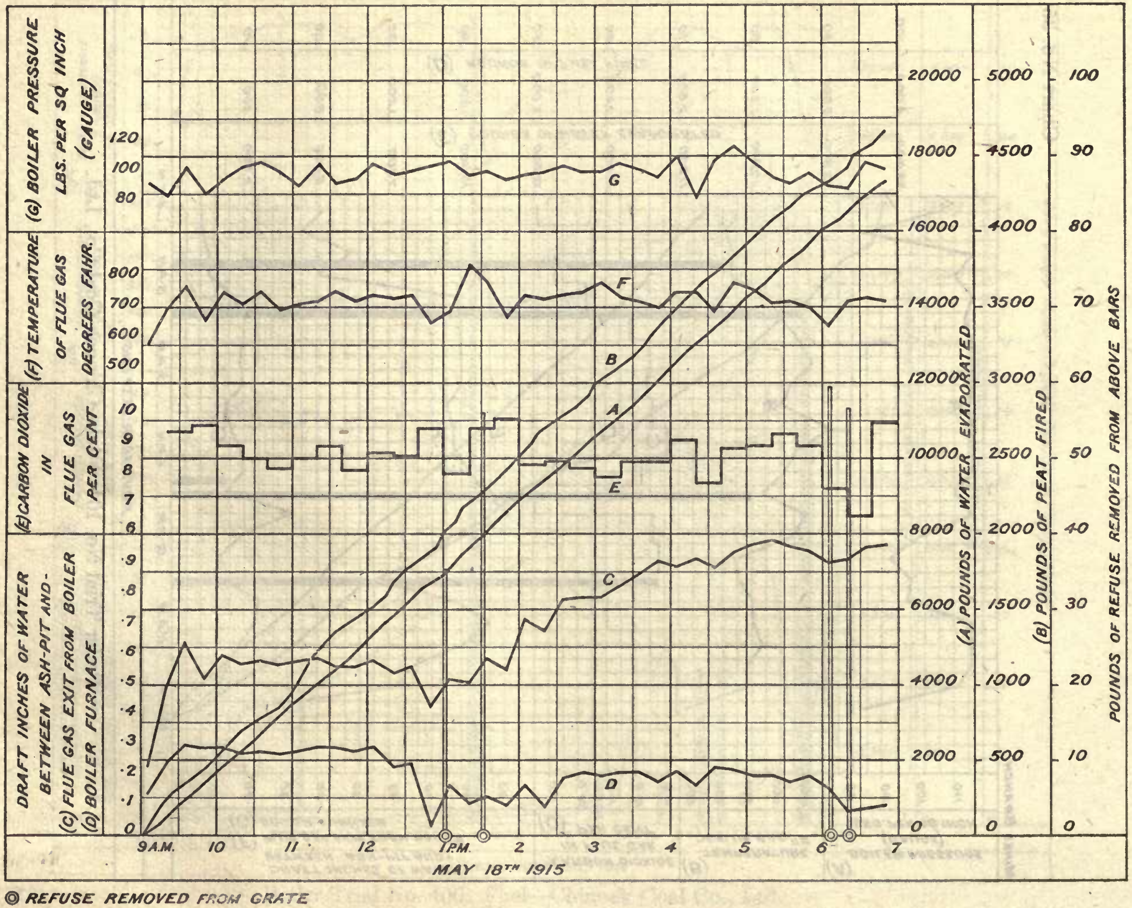
Boiler Trial No. 100: Fuel—Chinook Coal Co., Ltd.

Chart No. 35.



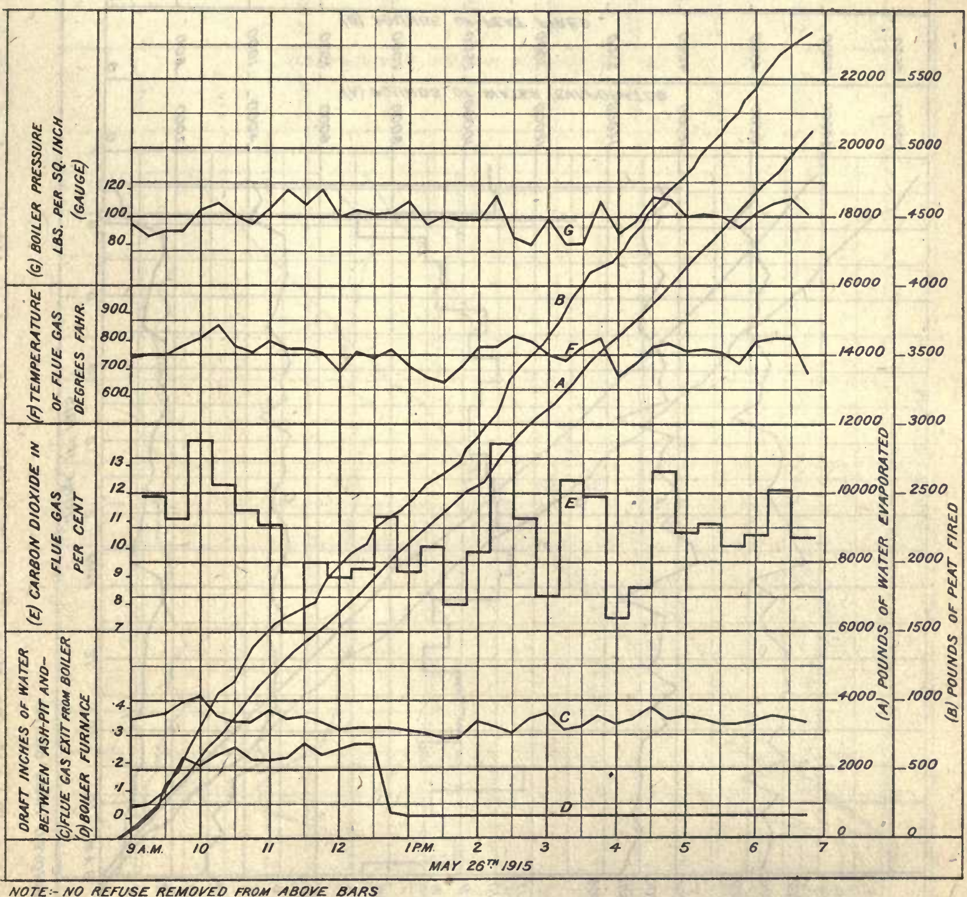
Boiler Trial No. 101: Fuel—Chinook Coal Co., Ltd.

Chart No. 36.



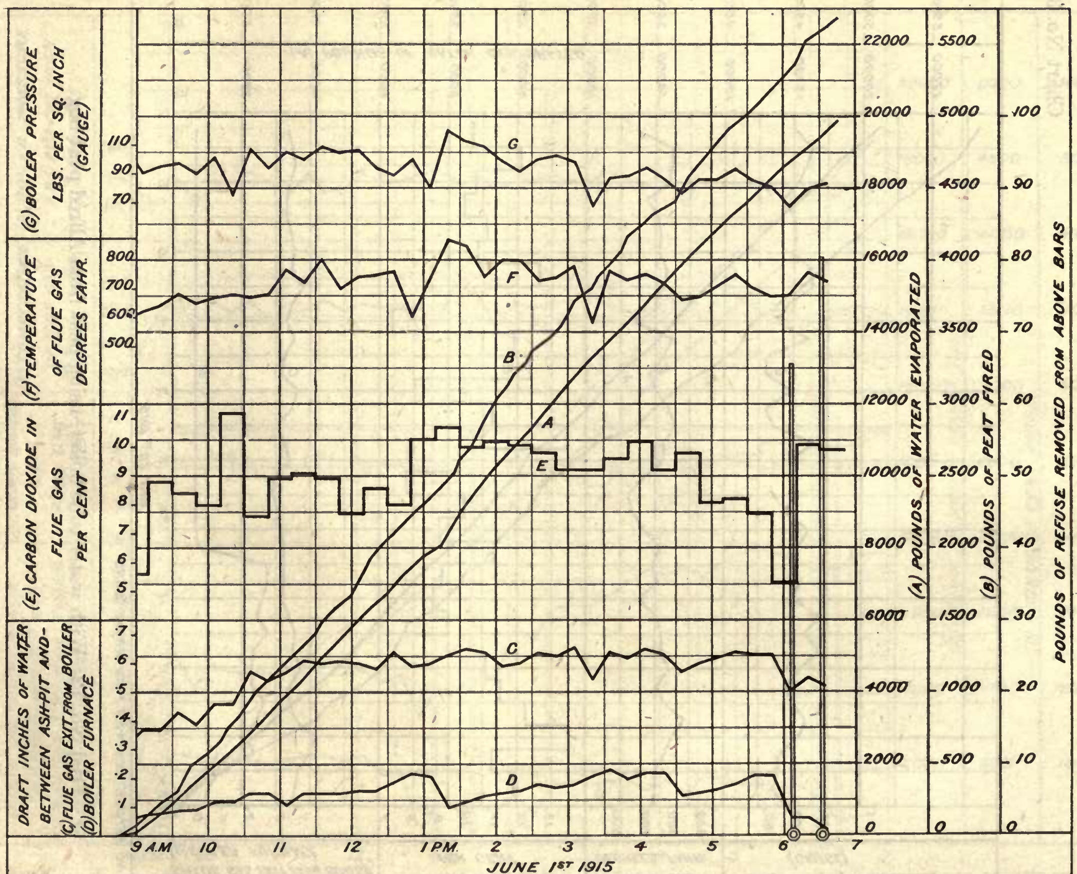
Trial No. 71: With water tube boiler, using peat from Alfred peat bog.

Chart No. 37.



Trial No. 72: With water tube boiler, using peat from Alfred peat bog.

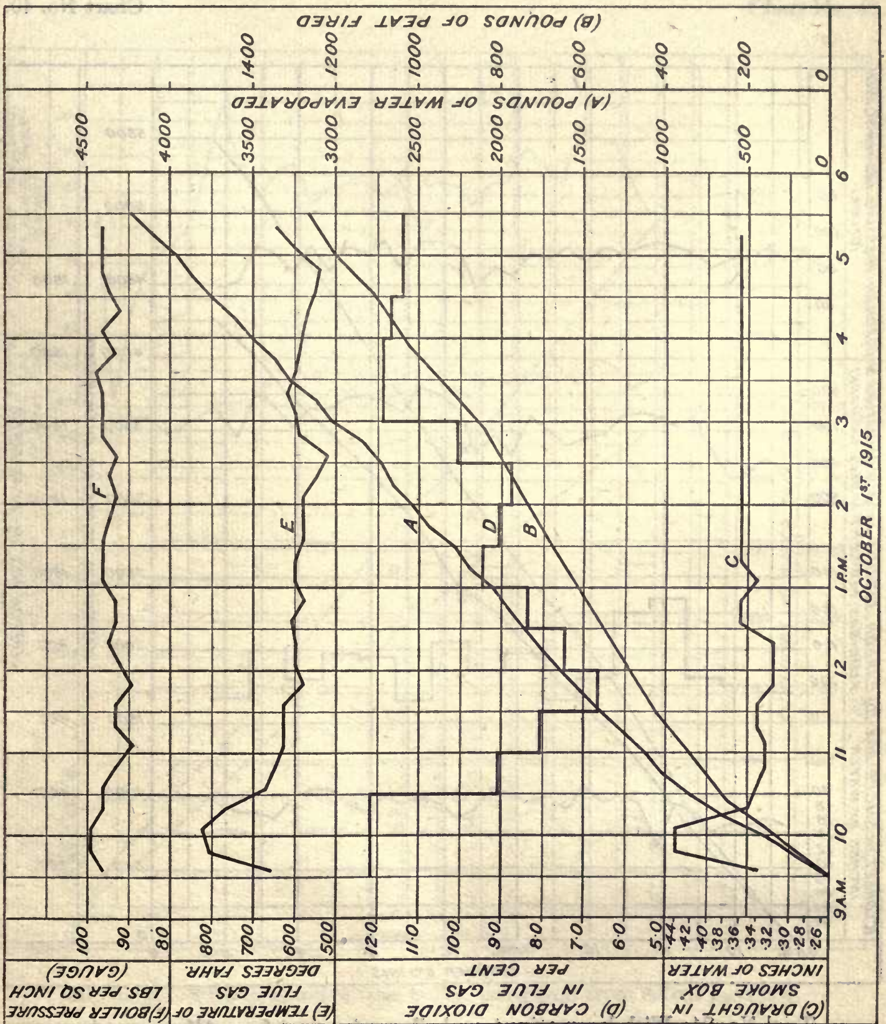
Chart No. 38.



◎ REFUSE REMOVED FROM GRATE

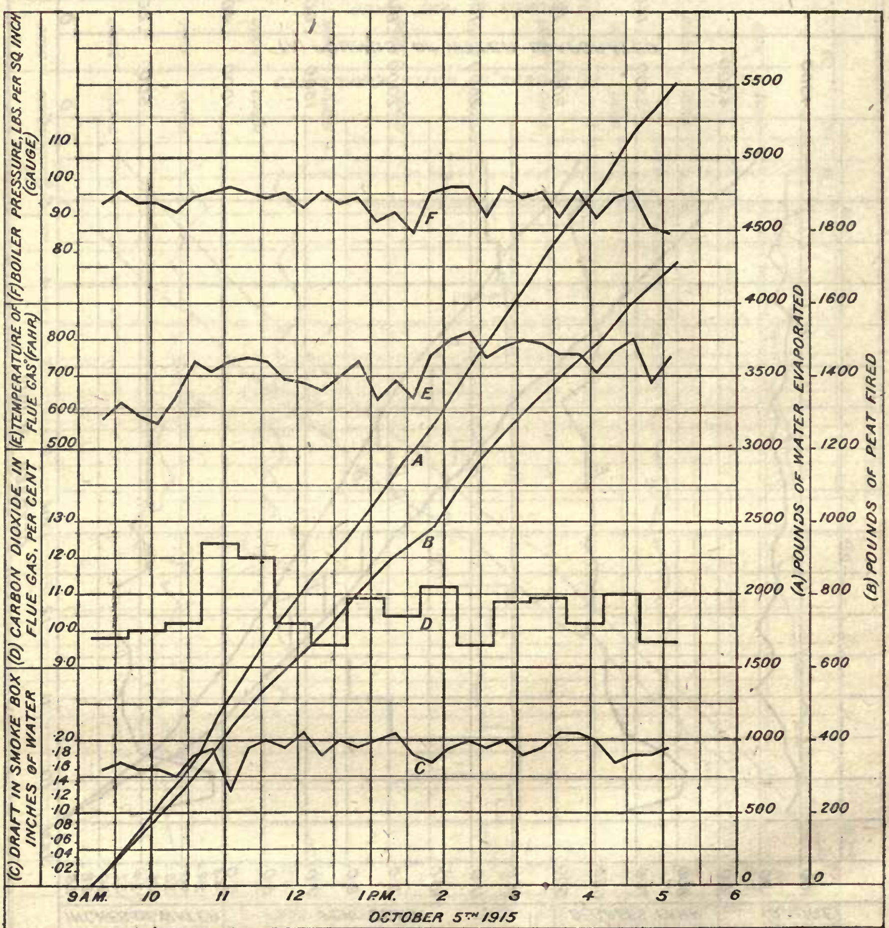
Trial No. 73: With water tube boiler, using peat from Alfred peat bog.

Chart No. 39.



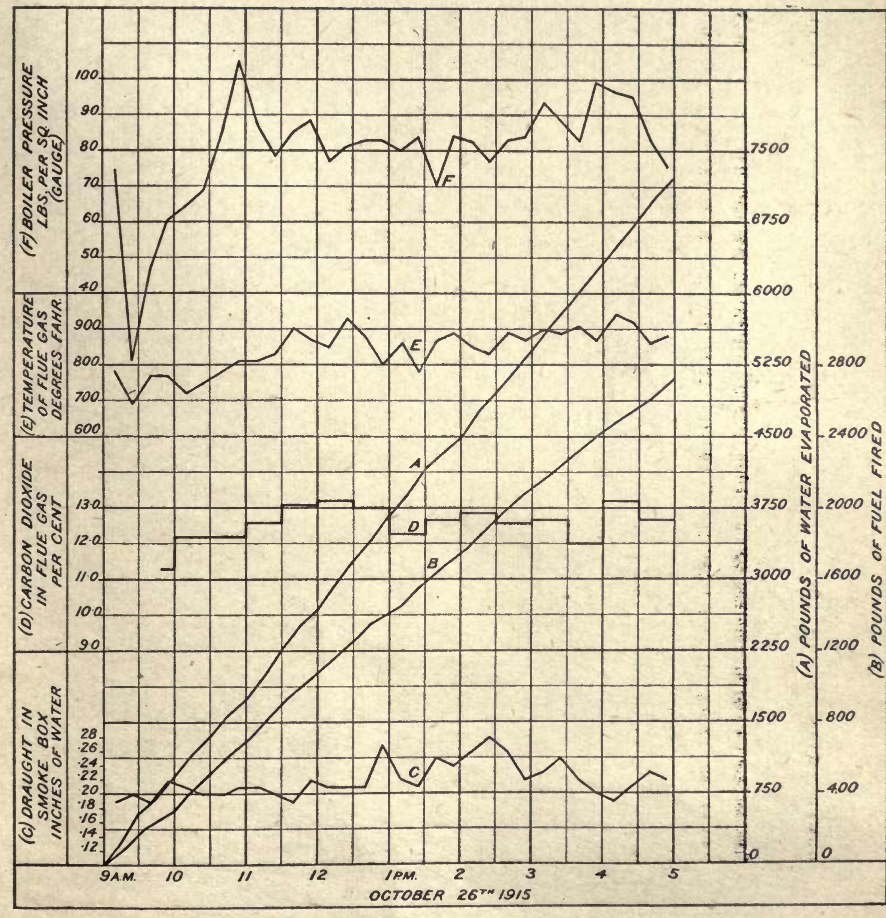
Trial No 83: With locomotive type boiler, using peat from Alfred peat bog.

Chart No. 40.



Trial No. 84: With locomotive type boiler, using peat from Alfred peat bog.

Chart No. 41.



Trial No. 85: With locomotive type boiler, using peat from Alfred peat bog.